AN INTEGRATED INFORMATION SYSTEM TO SUPPORT ENERGY POLICY FORMULATION IN SOUTH AFRICA: A CONCEPTUAL STUDY

by

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SUMMARY

The underlying assumption of this thesis is that information is critical for effective energy policy support. The objectives set and attained for this study were to:

- assess existing solutions to the problem of supplying energy information;
- consider developments in integrated conceptual solutions to the problems;
- identify and analyse data structures for providing a single integrated information system as a solution;
- evaluate and identify local energy and economic data sources for input to the proposed system;
- provide a framework for information outputs in such an integrated system; and
- make recommendations on the practical implementation of the conceptual solution.

The concepts underlying the basic assumption, and other parameters were clarified in Chapter 1. In particular, the link between policy formulation, modeling, and data collection, management and dissemination was shown.

A study and assessment of existing energy information systems was then carried out. This investigated national systems in South Africa and other countries, and the systems of three international organisations. The structure and management of these energy information systems was assessed, as was the degree to which each provided the necessary support for policy formulation. Legislation was, where applicable, also considered. It was determined from this study and assessment that there were no integrated information systems to provide adequate information for energy policy makers through a single access point.

An integrated single access point system was postulated at the conceptual level in Chapter 3. The major contribution to this conceptualisation is the

concept of a single standardised referential data set. A single referential data set can be used to classify all data at every level of the proposed integrated national energy information system. This integrated approach supports policy formulation and allows for the most efficient use of national resources in maintaining information. The proposed system was considered as a data flow model, to provide an overview of the collection, processing and dissemination of data. Next, a system model was developed. This divided the system into two broad divisions: the central control functions, including the referential data set; and the data modules, which provide the structure for capturing and maintaining the collected data. The final stage in this chapter was the development of a data model which shows the relationships between the elements of the system model, particularly the relationship between the referential data set and all other data.

In Chapter 4, this data model was developed further to identify entity sets and their content descriptions. It indicates in tabular format the structure of the different system components, and then shows diagrammatically the high level linkages between these components. This analysis of the proposed system is the precursor to work by systems analysts who are responsible for the final design specifications for system software.

In Chapter 5 the objective was to determine sources of data for input to the national system. The South African energy economy was briefly studied and assessed for both supply and demand side information.

Finally in Chapter 6, a set of output templates was developed. Once fully implemented, these will provide system users with all the necessary information to support policy formulation. Desired outputs from a system must be known before the system is designed, and are therefor included.

OPSOMMING

Drie aspekte is vir die mensdom, die nywerheidsektor en die regering van groot belang: die sukses of mislukking van die nasionale en wêreldekonomieë; die verbetering, onderhoud of agteruitgang van die omgewing en die voortgesette voorsiening van energie. Hierdie drie aspekte is nie slegs onlosmaaklik aan mekaar verbonde nie, maar ook aan talle ander fasette van die moderne wêreld.

Ekonomiese sukses hang af van 'n voldoende voorraad bekostigbare energie om nywerhede te ontwikkel, te onderhou en te vergroot. Die voorsiening van energie lei tot die beskadiging van die omgewing, hetsy gedurende ontginning, verwerking of verbruik. Vanaf die begin van die industriële revolusie het die nywerheidsektor en die bevolking vinnig gegroei - en so ook energieverbruik. Terwyl opbloeiende ekonomieë die lewenstandaard van talle verhoog het, word almal deur die agteruitgang van die omgewing beïnvloed.

'n Energiebeleid behoort só geformuleer te word dat dit tot die optimale benutting van energiebronne lei. Ekonomiese groei behoort gestimuleer en die omgewingsimpak van energieverbruik terselfdertyd verminder te word.

Inligting is geïdentifiseer as die eerste en mees kritiese komponent van die beleidsformuleringsproses. Die tekort aan beide inligting en 'n inligtingstelsel om die Suid-Afrikaanse analis van voldoende inligting in 'n geïntegreerde formaat te kan voorsien, is as kommerwekkend geïdentifiseer. Die uitdaging is om alle inligtingsvereistes te bepaal en dit in 'n stelsel te integreer wat aan beleidmakers en analiste met behulp van 'n enkele toegangspunt die vereiste inligting sal voorsien - en om die konseptuele raamwerk van sodanige stelsel te ontwerp.

Die doelwitte van dié studie is om:

- bestaande energie-inligtingoplossings te beoordeel;
- ontwikkelings van geïntegreerde konseptuele oplossings te oorweeg;
- datastrukture vir die voorgestelde geïntegreerde energie-inligtingstelsel te identifiseer en te ontleed;
- die plaaslike ekonomie en inligtingsbronne te identifiseer en te beoordeel;
- 'n raamwerk vir inligtingsuitsette in 'n geïntegreerde stelsel te skep; en
- aanbevelings vir die praktiese implementering van die oplossing te doen.

Drie moontlike modelle vir 'n nasionale energie-inligtingstelsel is geïdentifiseer. Dit is hoëvlak-bestuurstelsels - d.w.s. institusionele strukture wat 'n regering in staat sal stel om inligting te bestuur. Die voor- en nadele van elk is beoordeel en hulle toepaslikheid vir Suid-Afrika kortliks oorweeg.

Die strukture, inhoud en wetgewingsondersteuning van energiedata in sewe verskillende nasionale stelsels is daarna beoordeel. Inligting vanuit die VSA, VK, Kanada, Australië, Nieu-Seeland, Taiwan en Japan is gebruik. Internasionale organisasies wat energiedata inwin en versprei, is ondersoek en hulle stelsels beoordeel. Hierdie nasionale en internasionale stelsels is gebruik om vas te stel watter data ingewin word, deur wie, en of enige geïntegreerde stelsels bestaan om beleidsformulering te ondersteun.

Verskeie databasisse word in die wêreld bedryf. Die meerderheid is alleenstaande stelsels met weinig integrasie. Die realiteit is egter dat baie van die uitsette in der waarheid gekoppel is. Die VSA se nasionale databasisse dien as voorbeeld. Meer as een databasis moet dikwels gebruik word om die nodige inligting vir 'n verslag of analise te bekom. Dit is lomp en tydrowend. Soms is dit onmoontlik om inligting rekenaarmatig saam te stel omdat verskillende klassifiseringstandaarde gebruik is, of omdat apparatuur of

programmatuur teenstrydig is. Data moet dus per hand bekom en gemanipuleer word, wat dikwels neerkom op die hervaslegging van data, soos dit in SA (en ander lande) die geval was. In baie lande, soos in SA, word alle relevante data nie eens ingesamel nie – wat nog te sê in 'n nasionale databasis opgeneem. Internasionale instansies poog om sekere standaarde ten opsigte van die aard, hoeveelheid en formaat van data-inwinning te bevorder.

Die identifisering en kort beoordeling van die strukture, inhoud en wetgewing ten opsigte van energie-inligtinginwinningstelsels in Suid-Afrika vorm die eindkomponent van die studie van bestaande inligtingstrukture. Die vier hoofenergiesektore is in berekening gebring, asook die nasionale organisasies wat by data-inwinning en -bestuur betrokke is. 'n Kort beoordeling van aanbod- en vraagkantmetodes van data-inwinning vir Suid-Afrika is ook gedoen.

Die beleidmaker behoort te verstaan dat magtigingswetgewing gevestig moet wees, ten einde data-insamelingspogings te vergemaklik. Sodanige wetgewing behoort voorsiening te maak vir: wie uiteindelik verantwoordelik is vir die inwinning van data en die verspreiding van die geanaliseerde inligting; die gebruik van buiteliggame waar nodig; strafmaatreëls teen nie-verskaffers van data; en afdwingbare vertroulikheid ten opsigte van data wat ontvang is.

Die doeltreffendste manier om 'n nasionale stelsel te bestuur, is om van deskundige analiste binne 'n sentrale struktuur of agentskap gebruik te maak. Sodanige agentskap behoort die insameling van data vir alle energiebronne te definieer en te bestuur. Dit behoort ook te verseker dat alle data volgens nasionale en internasionale standaarde en behoeftes geklassifiseer word.

Die uitdaging is om 'n raamwerk te skep waarbinne alle data aan 'n gestandaardiseerde verwysingsraam gekoppel kan word. Beleidmakers, analiste, nywerheidsbeplanners en beleggers sal sodoende in staat gestel word om relevante inligting oor alle fasette van die nasionale energie-ekonomie met behulp van 'n enkele gebruikerskoppelvlak te bekom.

Hoofstuk 3 bied 'n breë oorsig oor en ontleding van die konseptuele ontwerp van 'n geïntegreerde nasionale energie-inligtingstelsel. Die onderwerp en voorgestelde oplossing is ingewikkeld en verskeie uitgangspunte geld. 'n Van-bo-na-onder-benadering is gekies omdat dit die mees logiese en doeltreffende inleiding tot en ontleding van die konseptuele ontwerp bied.

In die breedste oorsig, is die stelsel eers as 'n datavloeimodel beskou. Drie stadiums word beskryf, naamlik insameling, verwerking en verspreiding van data.

Die tweede oorsig, of stelselmodel, sit die inhoud van die stelsel uiteen. Die stelselinhoud is die logiese eenhede binne die stelsel wat gedurende die ontwerpproses geskep is. Dit definieer wat die stelsel sal doen, hoe dit sal funksioneer en watter data daarbinne gestoor sal word. Daar is twee afdelings binne die stelselmodel, naamlik eerstens verwysingsdatastelle en bestuursfunksies en tweedens die datamodules. Die eerste afdeling behels dus die sentrale beheerstrukture, terwyl die tweede die data wat ingewin word, vaslê en struktureer.

Vir die suksesvolle implementering van die stelsel wat vir die doel van hierdie studie ontwikkel is, was die konsekwente aanpassing van 'n enkele stel verwysingsdata in vier dimensies noodsaaklik, die dimensies synde: brandstoftipe, ekonomiese sektor, geografiese ligging en tyd. Dié vier dimensies word gebruik vir die klassifisering van alle data wat vasgelê word. Dit verseker dat enige data getrek en vergelyk kan word met behulp van 'n

gestandaardiseerde verwysingsraamwerk. Sover bekend, gebruik geen ander nasionale energiestelsel ter wêreld 'n enkele verwysingsraamwerk nie. Gestandaardiseerde uitsette by die formulering van 'n beleid is van onskatbare waarde.

Twee verdere, meer gedetailleerde datamodelle is ook ontwerp. Die modelle word gebruik om die hiërargiese aard van energieverbruik op konseptuele vlak te beskryf. Die eerste is die energievloeimodel wat die vloei van energie deur die ekonomie skets - vanaf die bron, deur ontginning, transformasie en verspreiding tot by die finale verbruik. Die tweede is 'n piramidiese model wat ontwikkel is om die struktuur en hiërargie van finale verbruiksektore te verklaar. 'n Eksterne programmatuurmaatskappy het die modelle wat die navorser ontwikkel het, gebruik om 'n prototipestelsel wat op statistiese energiedata fokus, te ontwerp.

Dit is noodsaaklik om al die verhoudinge wat binne die modelle ontwikkel is, te verstaan, aangesien dit andersins onmoontlik sal wees om die raamwerk vir die voorgestelde stelsel te ontwikkel.

Die data-elemente wat vir die stelsel benodig word, is geïdentifiseer en getabuleer. Dit is hoëvlakdata-analise en die beginpunt vir die tegniese ontwerpspesifikasie. Die verwantskappe tussen die verskillende datagebiede is ook ontleed, waarna die datamodel ontwerp is.

Dit is belangrik om die struktuur van die nasionale energie-ekonomie te verstaan vir beide beleidsformulering en die ontwerp en bevolking van 'n inligtingstelsel. Die energie-ekonomie sluit alle organisasies en individue in wat by die verskaffing, transformasie, verspreiding en verbruik van energie betrokke is.

Vir ontledingsdoeleindes is die ekonomie in aanbod-, vraag- en nie-energie-afdelings verdeel. Die doel was om 'n kort oorsig oor die aanbodkant en die geïnstalleerde kapasiteit te verskaf, asook 'n aanduiding van verbruik en 'n kort analise van bronne van nie-energiedata. Voldoende inligting om die datastrukture te bevolk word nie verskaf nie, aangesien dit slegs nodig sal wees wanneer die voorgestelde stelsel ten volle geïmplementeer is.

Aanbodkantdata kan by energieverskaffers en -verspreiders ingesamel word. Hierdie bronne is in Hoofstuk 5 uiteengesit. Waar moontlik, word 'n aanduiding van huidige (en historiese) produksie, kapasiteit, infrastruktuur en koppeling met ander organisasies verskaf. Sodanige inligting het ten doel om insig in die SA energie-ekonomie te verskaf volgens 'n van-bo-na-onder-benadering. Dit bied ook 'n beginpunt vir aanbodkantdata-insameling en -vaslegging vir die voorgestelde stelsel indien dit formeel geïmplementeer sou word.

Vraagkantdata kan by individuele verbruikers, voorsieners en verspreiders ingesamel word. Die mees gedetailleerde vraagkantdata word by individuele verbruikers verkry, hetsy organisasies, vervaardigers, huishoudings of ander bronne. Daar is ongelukkig tans min data op hierdie gedisaggregeerde vlak beskikbaar. Meer geaggregeerde vraagkantdata in die vorm van vekoopsinligting is by verskaffers en verspreiders beskikbaar. Data vanaf hierdie bronne word as insetdata aangedui. Verkoopsdata vir vloeibare brandstof word verskaf vir die tydperk 1985 tot 1997. Dit is die eerste formele publikasie van heelwat van hierdie data.

'n Onderwerp wat nie die aandag wat dit verdien, binne huidige inligtingstelsels en modelleringspogings ontvang nie, is die verbruik van nie-konvensionele energiebronne. Inligting is feitlik onbekombaar. Buiten dat dié feit vermeld word, word geen verdere insetbesonderhede verskaf nie. Tekstuele, nie-konvensionele energiedata kan in die energie-inligtingstelsel in

die "plattelandse energie"-module geplaas word. Waar statistiese data beskikbaar is, kan dit aan die relevante brandstof in die energiedatamodule gekoppel word.

Laastens is bronne vir beide makro- en mikro-nie-energiedata geïdentifiseer.

Die konseptuele raamwerk van hierdie studie is afgerond met die beskrywing van stelseluitsette in Hoofstuk 6. Terwyl 'n stelsel se uitsette die eindresultaat van die prosesse van die betrokke stelsel verteenwoordig, word die totale ontwerpproses in werklikheid deur die verlangde stelseluitsette bepaal. Dit is noodsaaklik om bewus te wees van watter inligting by die uitsette ingesluit behoort te word, ten einde die data wat vir die voorgestelde geïntegreerde stelsel ingewin en ingesluit behoort te word, te kan definieer.

Verbruikers benodig 'n stelsel wat hulle in staat sal stel om inligting te soek en te kry met behulp van spesifieke soekparameters. Sodoende kan die formaat van uitsette wat vir verdere ontleding verkry kan word, bepaal word. Die navorser weet uit ondervinding dat uitsetformate soms baie rigied en gestandaardiseerd is, sommige half-buigbaar en ander ten volle buigbaar. Daar word voorgestel dat die stelselontwerp die verskillende formate in berekening bring.

Die hoofuitsetgebiede wat ontwikkel en bespreek word, behels dié wat as die belangrikste vir beleidsanaliste beskou word. Aangesien die verhoudings en verwantskappe tussen modules ingewikkeld is en individuele verbruikers spesifieke uitsette kan benodig, sal addisionele analiste moontlik bykomende uitsette moet ontwikkel. Dit is dus belangrik dat die stelsel voldoende buigsaam moet wees om verdere uitbreiding te akkommodeer.

Een onderwerp is nie in diepte bespreek nie, naamlik die gebruik van geografiese inligtingstelsels (GIS'e). Dit is 'n baie breë onderwerp en 'n

studieveld in eie reg. 'n GIS is 'n baie nuttige instrument, veral waar data 'n geografiese (ruimte-) dimensie het. Heelwat uitsette uit die voorgestelde stelsel kan aan 'n GIS gekoppel word.

Dié studie is tot die konseptuele ontwerp van 'n geïntegreerde energie-inligtingstelsel vir SA beperk. Dit was nie moontlik om 'n volledige bedryfstelsel te ontwikkel en te implementeer nie. 'n Beperkte prototipestelsel is egter ontwikkel en bedryf. Die voorgestelde raamwerk kan as vaste basis vir die ontwikkeling en implementering van nasionale of internasionale stelsels dien.

Die studie hou twee belangrike implikasies in. Eerstens impliseer die feit dat geen geïntegreerde stelsel bestaan nie, dat dit óf nie moontlik óf nie gewens is nie. Die konseptuele ontwerp wat in hierdie studie voorgestel word, toon egter dat dit teoreties wel moontlik is om sodanige stelsel te implementeer. Hoewel geen nasionale of internasionale stelsels tans geïntegreer is nie, blyk die wenslikheid van integrasie duidelik, indien meer as een databasis gebruik word om data vir nuttige uitsette saam te stel.

Dit gee aanleiding tot die tweede groot implikasie. Indien dit beide moontlik en wenslik is om 'n geïntegreerde stelsel te ontwerp, is die implikasie dat dit moeilik is om so 'n stelsel te implementeer.

Twee aanvanklike vereistes word vir die implementering van die voorgestelde stelsel gestel. Eerstens behoort 'n sentrale liggaam verantwoordelik te wees vir die stigting en bedryf van die stelsel. Tweedens behoort wetgewing die proses te vergemaklik. Die sentrale beheer en bestuur van energie-inligtinginsameling, -analise en -verspreiding is 'n voor die hand liggende implikasie van 'n enkele nasionale inligtingstelsel. Sonder die nodige wetlike raamwerk sal die implementering daarvan egter haas

onmoontlik wees. Voorgenoemde impliseer dat geen sodanige stelsel sonder die belangstelling en ondersteuning van die staat bedryf sal kan word nie.

Die vernaamste redes waarom 'n enkele stelsel nie implementeerbaar is nie, het te make met die groot probleem dat dit baie moeilik is om data met verskillende eienskappe vas te lê en via 'n enkele toegangspunt te onttrek. Per implikasie sal die voorgestelde stelsel hierdie struikelblok moet oorkom om van enige nut te wees. Die kernkonsep wat dit moontlik sal maak om 'n geïntegreerde nasionale energie-inligtingstelsel te implementeer, is 'n enkele verwysingsdatastel wat die kern van die kontrolefunksies van die voorgestelde stelsel is.

Na die bepaling van die verwysingsdatastel vir die voorgestelde stelsel en 'n beginselooreenkoms dat 'n enkele beheerliggaam wat deur wetgewing ondersteun word, behoort te bestaan, is daar 'n verdere struikelblok in die pad van implementering: om 'n nasionale stelsel soos in hierdie studie voorgestel word, op te stel, sal duur wees. Die onderhoudskoste daarvan sal ook hoog wees. Sou die staat besluit om die stelsel te implementeer, behels die finale implikasie 'n langtermynverbintenis tot die ontwikkeling van kundigheid, data-insamelingsprogramme en stelselonderhoud. Hierdie beleggings sal veel omvangryker wees as die aanvanklike belegging om die stelsel in bedryf te stel.

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LIST OF ABBREVIATIONS USED

AEIS	African Energy Information System
ASM	Annual Survey of Manufacturers
b/d	barrels per day
Btu	British thermal units
CADDET	Centre for Analysis and Dissemination of Demonstrated Energy Technologies
CBECS	Commercial Buildings Energy Consumption Survey
CEC	California Energy Commission
CHP	Combined Heat and Power
CO_2	Carbon dioxide
CSIR	Council for Scientific and Industrial Research
CSS	Central Statistical Service (former name for Stats SA)
DME	Department of Minerals and Energy
DMEA	Department of Mineral and Energy Affairs
DSM	Demand side management
EDRC	Energy for Development Research Centre
EIA	Energy Information Administration
ERI	Energy Research Institute
ETSU	ETSU (previously named Energy Technology Support Unit)
GDP	Gross Domestic Product
GEIS	Global Energy Information System
GGP	Gross Geographic Product
GIS	Geographical Information System
GJ	Gigajoule (10^9 J)
GWh	Gigawatt hour
IEA	International Energy Agency
IES	Institute for Energy Studies
ISIC	International Standard Industrial Classification
ISIS	Information System on Industrial Structures
J	joule
k*l*	kilolitre (thousand litres)
kt	kiloton (thousand tons)
m^3	cubic metre
MCDM	Multicriterion decision method
MECS	Manufacturing Energy Consumption Survey
MJ	Megajoule (10^6 J)
M*l*	Megalitre (million litres)
Mt	Million metric tons
MW	Megawatt
ncmph	normal cubic metres per hour
NEMS	National Energy Modelling System
NER	National Electricity Regulator
NRCan	National Resources Canada
OECD	Organisation for Economic Co-operation and Development

PCE	Private Consumption Expenditure
PJ	Petajoule (10^{15} J)
RAU	Rand Afrikaans University
RECS	Residential Energy Consumption Survey
SA	South Africa
SADC	Southern African Development Community
SAPIA	South African Petroleum Industry Association
SIC	Standard Industrial Classification (local adaptations of ISIC)
Stats SA	Statistics South Africa
TAU	Technical Support Unit
TBVC	Transkei, Bophuthatswana, Venda and Ciskei
tce	Ton coal equivalent
TCOA	Transvaal Coal Owners Association
TJ	Terajoule (10^{12} joule)
toe	Ton oil equivalent
UCT	University of Cape Town
UK	United Kingdom
UNIDO	United Nations Industrial Development Organisation
USA	United States of America
WEC	World Energy Council

CHAPTER 1: INTRODUCTION

1.1 CONTEXT

Three major concerns for society, industry and government are: the success or failure of national and world economies; the improvement, maintenance or degradation of the environment; and the continued provision of energy. These three are inextricably connected, not only to each other, but also to all other facets of the modern world.

Economic success depends, in many ways, on a sufficient supply of affordable energy to develop, maintain and enlarge industries. Supplying energy has tended to be damaging to the environment, whether during the extraction, processing or utilisation phase. Since the start of the industrial revolution, industry and population have grown rapidly - as has energy consumption. While booming economies have improved the social lot of many, concomitant environmental degradation affects everyone.

During the initial years of the industrial revolution little attention was paid, by governments or industries, to either the probability of a continued supply of energy or the damage being done to the environment. This has changed dramatically. It is now realised that providing 'a sufficient supply of affordable energy' is a complex process, requiring ongoing and long-term planning. Government and industry can not simply open another coal mine or build a new nuclear facility - non-renewable resources are declining, costs are escalating and lead times at all levels of the energy industry are lengthy, all of which have implications for supply and affordability. Furthermore, it has become obvious that the environmental cost and impact of producing the energy should be calculated.

Population growth, societal needs and desires, industrial and economic vitality and environmental issues all place pressure on energy industries and national and international government agencies. This pressure is twofold: to guarantee the continued, affordable supply of energy and to minimise environmental impact. To do this it is necessary to plan, and planning requires information. Energy policy for the energy industry and concerned governmental agencies is formulated from this information. Moore and Rowlands (1991:8) noted that: "...it might be said that two of the most important characteristics of a developed society are the extent to which information is used to manage and support organisational life and the degree to which people use information as an integral part of their everyday lives."

Speaking on information in urban management, Cartwright (1989) (as quoted by Worrall, 1990:3) says: "Unless you intend to rely on blind luck, information is clearly crucial to urban management and decision making." This statement is as applicable to energy policy formulation as it is to urban planning. The formulation of an effective energy policy is largely dependent on a knowledge and understanding of past and current energy consumption patterns as well as on a quantification of probable future energy demand patterns. Added to this is the need for both a knowledge and quantification of environmental factors.

Carbon dioxide (CO_2) and methane, with four other gases, have been singled out as greenhouse gases of concern. The desirability of international reduction of all emissions was clearly indicated by the Earth summit at Rio de Janeiro in 1992 and the Kyoto follow-up in 1997. The energy industry, at all stages of exploitation, is responsible for large volumes of gaseous and particulate emissions. Policies designed to reduce emissions will require information: to determine past and current emission levels; to identify areas where changes need to be made; and to measure the efficacy of such changes.

From all the above, it is clear that resources should be allocated to information collection and that sufficient, pertinent data needs to be made available in a format which allows for adequate planning and policy formulation. In a study on general statistics and policy formulation in Sub-Saharan African countries, Chander (1990:1), concluded that: "Information gaps have adversely affected policy analysis and the decision making capacity of governments". More recently, and directly related to energy policy formulation, Kleinpeter (1995:8/9) noted: "A data base is a fundamental element of a planning exercise..."

The South African government is aware of the importance of information. In the White Paper on Energy Policy (Department of Minerals and Energy, 1998:75), the following statement is made: "Not only is good data required for the energy policy process, but it is fundamental to the implementation of integrated energy planning."

Integrated energy planning should be further facilitated if the data could be made available through a single integrated information system.

1.2 FORMULATION OF PROBLEM, GOAL AND OBJECTIVES OF THE STUDY

1.2.1 Problem statement

South Africa needs to generate and collate information on energy that will facilitate the formulation of an integrated national energy policy. This information should be made available via an information system that meets the national, industrial, economic, environmental and international requirements for policy formulation for the provision of energy. Currently no single system exists locally or internationally to provide such information.

Neither is all useful local energy information collected, and that which is collected is not made available optimally - ie via an integrated system.

The problem addressed by this study can be stated as follows:

Local and international energy data availability and energy information systems do not adequately meet this country's energy informational needs.

A that such a problem exists locally is shown in the International Energy Agency's 1996 evaluation of South Africa's Energy Policies (IEA 1996:64) and in the Governmental White Paper on Energy Policy in which the issue of inadequate information for planning purposes is noted (DME 1998:75).

B solving the problem has three parts

i) determining what current and future energy data requirements are nationally and internationally with respect to SA; examining systems and methods for meeting these requirements; deciding on the theoretically optimal solution; conceptualising this solution through a complete explication of the proposed system,

ii) evaluating this and other theoretical solutions practically by commissioning the required financial and economic feasibility studies,

iii) implementation of the desired solution.

This study proposes a solution to the first level of the problem by conceptualising an integrated solution to the country's energy information requirements, which will be a substantial improvement on current systems. In so doing the following problems will be addressed:

What mechanisms and systems are extant for monitoring energy data?
How do they operate?

What information do they make available?
In what ways do they succeed in their goals and in what ways do they fail?
Does a single access point, integrated system exist?
What outputs are required from such an information system?
In order to provide these outputs, what data should be collected?
How should this data be arranged, stored and made accessible?
Is an integrated, single access point energy information system possible?

The second and third levels of the problem are beyond the scope of this study, although appropriate attention is given to them where applicable.

1.2.2 Goal

The prime goal of this study is to develop and present a conceptual design for an integrated energy information system for use by policy makers and analysts. The focus is on the first stage of the decision making process, namely that of intelligence (data collection and capture, processing and dissemination), to provide government, industry analysts, investors and academics with information to support all aspects of the policy and planning processes.

1.2.3 Objectives

The objectives of this study are:

- To assess the existing solutions to the problem of supplying energy information.
- To consider developments in integrated conceptual solutions.
- To identify and analyse data structures for the proposed integrated energy information system.
- To evaluate and identify the local economy and data sources.

- To provide a framework for information outputs in an integrated system.
- To make recommendations on instituting the solution practically.

1.3 ASSUMPTIONS

The underlying assumption is that information is critical for effective policy support. Energy information is currently available from diverse data systems, or is not available at all. It is assumed therefor that there is a need for integrating as many of these data services as possible into a single integrated system. Further, it is assumed that it will facilitate analysis if all relevant data could be related to the same referential framework and classification data sets, being accessible through a single system interface.

It will be shown that there are no fully integrated systems operative in the world and the working hypothesis is that it is possible to create a framework for such a system.

1.4 DEFINING CONCEPTS - THE LINK BETWEEN POLICY, MODELS AND DATA

The concept of policy formulation can be compared to the decision making process. A basic model depicting the process of human decision making was developed by Ahituv and Neumann (1987:20). It proposed a three-stage process and illustrates the link between the elements of data, models and policy (Figure 1.1). These stages are:

- Intelligence : identification of problem and data collection.
- Model : quantification of alternative solutions.
- Choice : selecting a solution and monitoring its application.

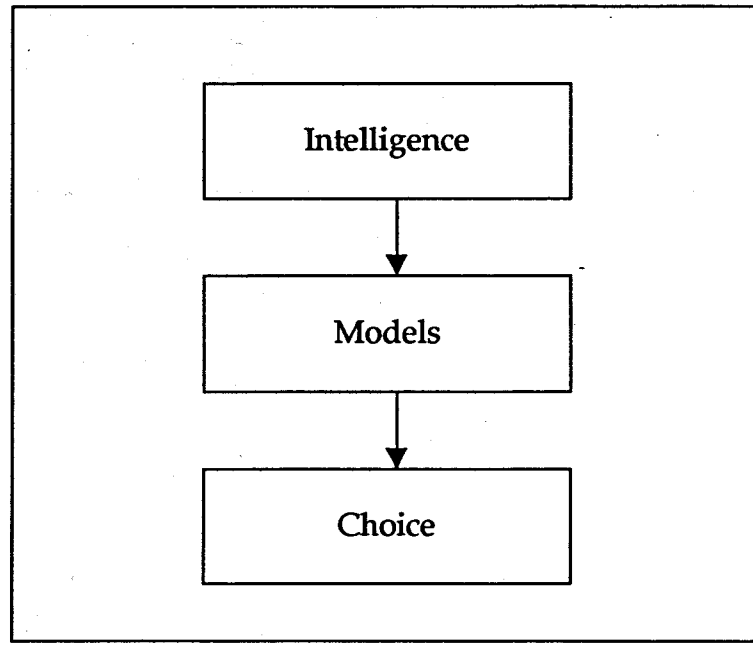


Figure 1.1: The decision making process (Ahituv and Neumann, 1987:20)

An understanding of the implications of each of these components will provide an important base for the processes and structures which will be analysed later.

1.4.1 Intelligence

'Intelligence' in decision making does not refer to intellectual capability but rather to knowledge or information. The policy maker becomes aware of a decision need or information deficit, often in the detection of a problem or the desire to seek opportunities. In the context of energy policy, examples could be the 1973 oil crisis as a problem and the utilisation of natural gas from the Bredasdorp Basin as opportunity seeking.

The specific reasons for information needs are generally unimportant to the intelligence gathering process, except when a new field of concern arises for which no data has been collected. The other components of the intelligence stage are more important on an ongoing basis. These are the collection,

classification, analysis and presentation of data required to support the later stages of the decision making process.

In the energy context it can be concluded that the data analysis phase should be an ongoing process to ensure that the basic structures and information are already in place to streamline the further decision making stages, should a problem or opportunity arise.

1.4.2 Model

In this stage the options are identified and the effects of each option are quantified. The data collected during the first stage are used as inputs to models which will quantify the effects of the various solutions or options which have been suggested. The effects of the possible solutions can then be examined under a specified set of criteria.

It is possible that a return to the intelligence stage will become necessary to redefine the options or collect more specific data, i.e. a feedback loop can occur.

Models can vary extensively in complexity, from very simple to very complex. Many different models have been developed for addressing the problem of quantifying future energy demand and for analysing the effects of different energy policy options on the demand for energy. Cooper (1988:6-22) provided a brief overview of some models used for policy purposes. Since 1988 the focus of modeling efforts has moved towards modeling the environmental effects of energy demand. One specific case is that of the United Kingdom where the official models have been modified to estimate CO_2 emissions (Miller, 1992). This trend has accelerated with an increased emphasis on energy and its environmental impact becoming apparent (World Energy Council, 1993:135-150; International Energy Agency, 1998d:53-58). The

Kyoto Protocol signed in December 1997 requires governments to take steps to reduce, in particular CO_2, emissions. These will need to be monitored, requiring data and models to predict reduction given specific policy options. Models (and their underlying databases) will thus need to provide quantitative data on both energy demand and related emissions.

One of the major limitations (indeed if not the most important limitation) to any modeling effort is the quality and detail of the data used as input to the model. Kotzé (1993) indicated that a project to create a detailed model for South Africa during the 1970's failed because the data was completely inadequate. Similarly Vermeulen (1994) noted that the MARKAL project of the late 1980's failed to meet the original aims, primarily because of a lack of sufficiently detailed data. The data requirements for any model should be determined and compared to available data before implementation. If the required data can not be obtained, nor reasonable estimates made for gaps, then model implementation should be suspended or cancelled until such time as the data can be collected. Methods for ensuring adequate data collection will be dealt with in Chapter 2.

Once the modeling options have been quantified, the third and final stage is reached.

1.4.3 Choice

In this stage the policy maker is faced with making a choice from among the alternatives generated in the model stage. This is the stage where policy options are evaluated and formulated for implementation. While this appears relatively easy, there are a number of obstacles which can make this stage very complex. Ahituv and Neumann (1987:21-22) mentioned the following five obstacles which could affect the choice stage:

(i) Multiple preference

The outputs could indicate options where the final outcome, using a desired route, may not be as desirable as the final outcome from a less desirable route.

(ii) Uncertainty

Often outcomes are uncertain and probabilities will need to be assigned to various outputs. This is not always an easy task and decisions may be compromised.

(iii) Conflicting interests

Some decisions are likely to affect some sectors negatively, while affecting others positively. Balancing these conflicting interests to ensure that long-term goals are met could mean short-term disruptions.

(iv) Control

Who will control the plan decided upon? If there is no control, the final outcome may not be what was originally envisaged.

(v) Team decision making

A decision that satisfies all segments of the population is more difficult to successfully achieve and implement than one that satisfies only one sector. This is similar to the 'conflicting interests' obstacle.

The options developed, and affected by the obstacles noted above, may be such that a return to the model stage, or even the intelligence stage, becomes necessary to ensure that the ultimate strategies are accepted by all essential role players.

Figure 1.1 can be redesigned to indicate that the process is iterative and applicable to energy policy formulation. With energy policy, the process is effectively never-ending, because responses to continually changing stimuli

are required. Duga, Malone and Davis (1976:31) developed a model for State energy policy in the USA, linking data, models and policy which incorporates the real world and conceptual models. This process is given in Figure 1.2.

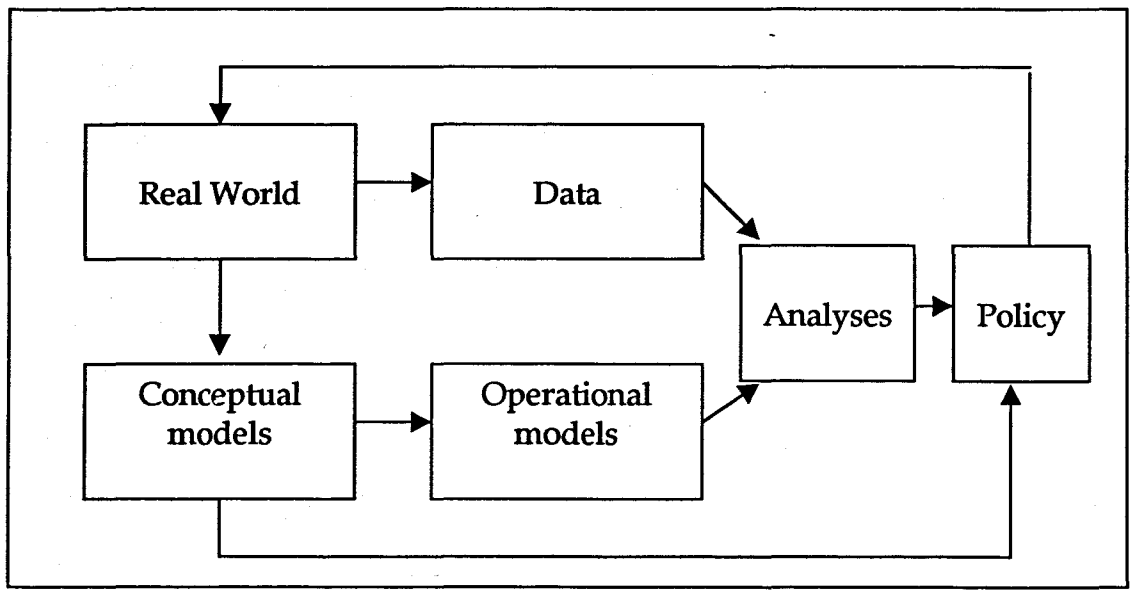


Figure 1.2: Diagram of feedback loop in energy policy formulation (after Duga et al, 1976:31)

1.4.4 Concept of a single information system

The important role that information plays in the policy making process should be clear from all the above. This thesis develops and evaluates the idea that it is possible to maintain all the necessary data within one information system, accessible through a single access point.

A study of international systems indicated that most countries have information systems in place but that these are either non-integrated or poorly integrated. The data is usually stored in different physical databases and data extraction for analytic purposes is tedious, often requiring recapture and realignment of data to permit analysis. Some systems have been designed to address a particular and specific problem and are thus inflexible when new

users attempt to access them. Many systems currently in use can be termed "legacy systems" which were developed after the 1973 oil crisis, and are based on large mainframes requiring specialised programming for the generation of reports (Herhal, 1998).

Technological advances in the computer industry, particularly in the last few years, have made the physical development of an integrated information system feasible at relatively low cost. The full economic implications of implementing an integrated system will however have to be analysed by the relevant governmental agencies. This study attempts to determine the desirability of an integrated system in terms of data, models and policy. This integration of databases will facilitate all analyses required for policy formulation. Reduced workloads in reclassifying and recapturing data plus the speed with which routine and one-off reports can be made using such a system should make it economically viable. The desirability of a system using one referential framework accessed through a single point was discussed with a senior analyst at the United States' Energy Information Administration during a personal visit (DeMouy, 1998). He noted that such a system would greatly facilitate and simplify the analysis process within that organisation. Economic and financial aspects will be addressed where appropriate.

A system which could be considered a prototype of the integrated system proposed in this thesis was reported by Karni, Feigin and Breiner (1992). They reported on the development of a system to assist Israeli energy policy makers using a multicriterion decision method (MCDM). The system was not fully integrated as not all possibly useful data was captured, nor did the system integrate with or replace other extant systems. Nevertheless, the mechanism of the MCDM in Israel suggests that a wide range of data and information was required for the exercise and that further additions were envisaged as possible. The case study was intended for electricity pricing policy, although other potential subjects were identified. The data inputs were

not limited to electricity price but, from the list of goals provided, also included alternative electricity sources, reduction in intensity of energy use, different spatial location of consumers with different climatic conditions, development of industrial infrastructure, and more (Karni et al, 1992:31). A central research team coordinated and directed the research, and methodology and system architecture was developed by this team and various expert groups. They formulated goals and defined policy areas where decisions were required.

By implication a more comprehensive system using all energy data is both feasible and operationally desirable from the energy analyst or policymaker's point of view. Cost-benefit calculations, determination of investment levels and other financial and economic feasibility studies are beyond the scope of the thesis, as is a full exploration of the software and hardware parameters.

1.5 RESEARCH METHODOLOGY

The focus of the study is energy information system design and usefulness. The methodology followed was cross-sectional: examining current systems to determine their content and boundaries; determining whether there were any integrated systems or attempts at integrated systems, or whether the need for an integrated system had been expressed; and considering the required outputs and raw data inputs for an integrated system. The research aim was exploratory and the result is the conceptualisation of an integrated information system which should fulfil all the requirements for data to support energy policy formulation via a single access point. The concept of this system is brought to the point where detailed economic assessment and cost-benefit evaluations, software design and practical application can begin. Although based on South African data, the concept is internationally applicable and the Southern African Development Community (SADC) has expressed interest in using the concept for a regional system.

There seems to be no standard definitions within the energy statistics environment for terms such as structure, infrastructure and system and what they describe. The United Nations (1991:17-21) uses the terms 'infrastructure' and 'structure' not only to describe the structures in place within a country for managing energy information, but also to describe the structures for individual energy surveys (UN, 1991:20/21). The Energy Information Administration tends, in general, to use the term 'system' to describe their data and information management processes, usually referring to individual programs as 'systems', although the entire energy data progammes could be called a system. In his text on systems Athey (1982:12) defined a system as "...any set of components which could be seen as working together for the overall objective of the whole." A similar description was used in relation to information processing systems by Davis (1981:408) when he noted "...all systems are composed of a number of interrelated parts that work together to perform some function." Rob & Coronel (1997:317) indicate that a system has a meaning referring to the software programs, database files and user interfaces interacting in a logical manner which are required to provide the ability to store, maintain, manipulate and extract captured data to provide the user with information suitable for further analysis. In order to provide an understanding of the terminology used in the thesis' framework, the following terms are explained to avoid any confusion caused by different possible meanings.

The **infrastructure** of a country refers to the network of basic services in place. This societal foundation includes public and private physical structures such as roads and pipelines, and information and aid services such as schools and hospitals. In terms of national energy information, **infrastructure** includes the physical, legislative, human resources, software systems and data collection framework for collecting, classifying, maintaining, analysing and disseminating energy and energy related data and information.

In general in this thesis the term system refers to the software programs needed to ensure that the data can be captured, maintained, classified, manipulated and extracted for dissemination or for further analysis. It also refers to the outputs produced. The term integrated system refers to a system where a number of data modules, or sub-systems, are linked through the use of a single referential framework, preferably through a single access point, to ensure that manipulation and extraction of data and information can be done in a uniform manner to facilitate further analysis.

1.7 RESEARCH FRAMEWORK

(i) Introduction

Chapter 1 gives the context against which this study is predicated. The goal and objectives are listed and the research assumptions, concepts and framework are detailed.

(ii) Study and assessment of existing solutions

The task of developing the integrated system starts with an assessment of existing infrastructure and systems in terms of management, structure and, where applicable, legislation. This will be done for systems from other countries as well as for South Africa. Identification of possible existing solutions also forms part of the analysis in Chapter 2.

(iii) Development of integrated conceptual solutions

Chapter 3 forms the core of the study. Here the concept for an integrated system, with all the areas for which information is required, is developed and presented. The objective is to develop a conceptual model for this system and the critical data relationships which are required for implementation. Also included in this chapter is the identification of a single referential data set required for statistical data classification.

(iv) Identification and analysis of data structures

Chapter 4 will focus on specific data analyses and identify logical entity sets and attributes contained within each set. The relationships between entities will be modeled. The objective for this chapter is to identify the attributes for which data will be collected.

(v) Assessment of local economy and identification of data sources

Chapter 5 will focus on a brief analysis of the South African energy economy to identify data sources. Statistical data at a high level of aggregation will be presented. Information extracted from a prototype system, (restricted to statistical energy data, and developed from a portion of the concept of the integrated energy system), will be made available.

(vi) Framework for information outputs

Chapter 6 deals with outputs from the system. These are critical and the framework for outputs is developed and presented. The objectives are to identify and define fixed format outputs, to define variable outputs and to set out a structure for derived and textual outputs.

(vii) Conclusion, summary, implications and recommendations

Chapter 7 presents a summary of the thesis. The limits and implications of the study are noted, and recommendations and proposals for continued research and practical implementation are given.

The above framework is depicted in Figure 1.3.

1.8 SYNTHESIS

The role of information has been identified as the first and crucial component of the policy formulation process. The lack of both information and an

information system to provide the South African analyst with sufficient information in an integrated form has been identified as being of concern. The problem is to identify all information requirements and to integrate these into a system which, through a single access point, will provide policy makers and analysts with the required information, and to develop a conceptual framework for such a system. Figure 1.3 lays out the design of the thesis, which encapsulates the above summary.

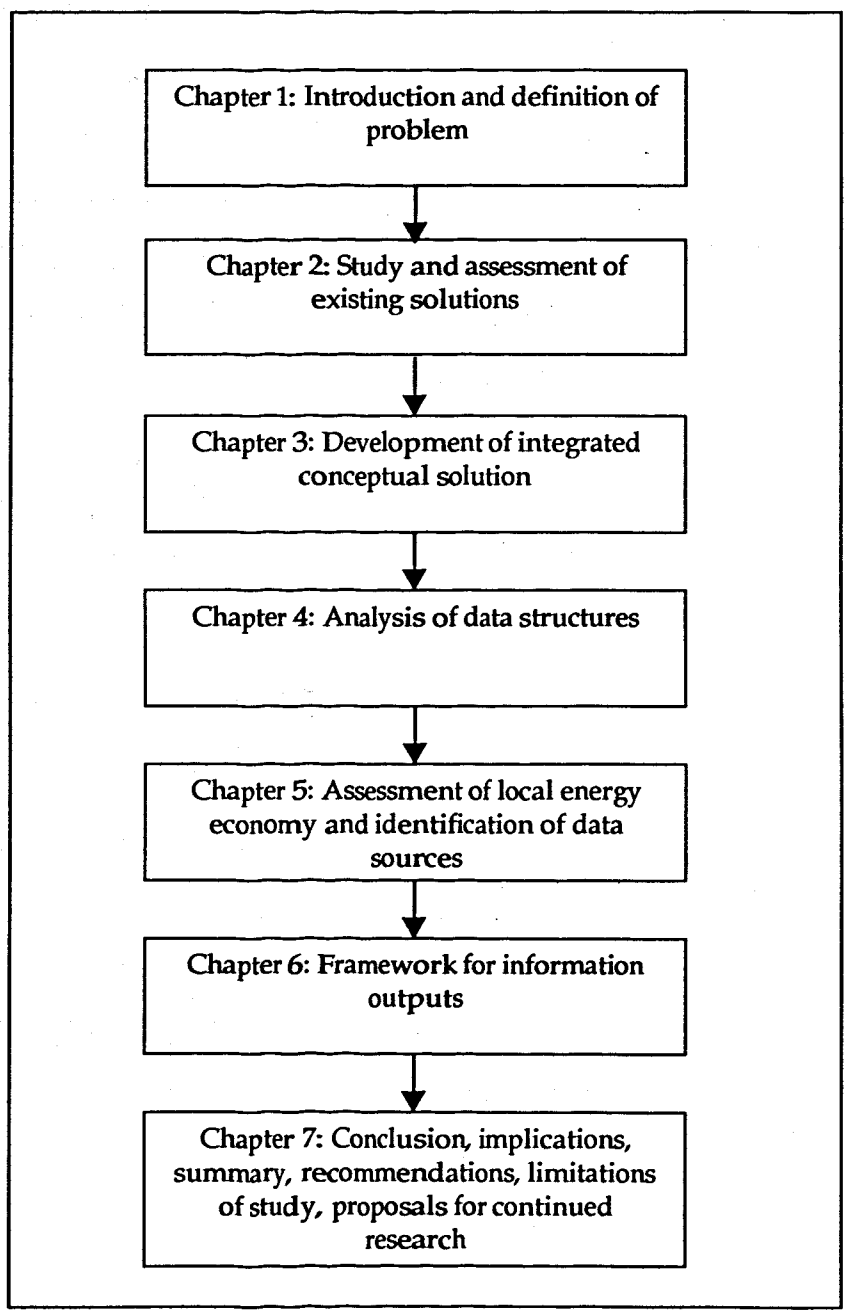


Figure 1.3: Diagrammatic framework for the study

CHAPTER 2: EXISTING INFORMATION INFRASTRUCTURES

2.1 INTRODUCTION

It is necessary to compile an energy consumption database before any meaningful analysis of the energy economy can be made. For energy policy formulation purposes such an analysis is the first key step to the development of a credible energy policy. This chapter considers systems for the collection, management and dissemination of energy information.

Three possible models for a national energy information infrastructure are identified. These are high level management systems i.e. institutional structures which allow a government to manage information. The advantages and disadvantages of the three systems are assessed, with a brief consideration of their applicability to South Africa.

An assessment of the structures, content and legislative support for energy data in seven different national systems is then carried out. Information from the USA, UK, Canada, Australia, New Zealand, Taiwan and Japan was used. International organisations involved in energy data collection and dissemination are investigated and their systems assessed. These national and international systems are used to determine what data is collected, by whom and whether any integrated systems exist to support policy formulation.

The final component, of this chapter, is the identification and brief assessment of the structures, content and legislation of South African energy information collection systems. The four main energy sectors are considered, as are national organisations involved in data collection and management. A brief assessment of supply- and demand-side approaches to energy data collection for South Africa (SA) is made.

2.2 ENERGY INFORMATION INFRASTRUCTURES

The United Nations presented a description, in 'Energy statistics: a manual for developing countries' (1991:17-21), of three basic methods which can be used by a government to create a national energy information infrastructure and physical system, these being:

- The national central statistical office may be responsible for collecting and disseminating energy data.
- The sub-ministry handling each fuel may be responsible for managing data related to that fuel.
- A central body within the energy ministry may be the authority.

These three infrastructural systems are assessed below, in relation to the situation in South Africa.

2.2.1 The use of a central statistical office

The use of the government central statistics office to collect and compile energy data has a number of distinct advantages. There are however some important disadvantages to be assessed.

i) Advantages

The central statistical office of a country has the responsibility and the legal authority to collect such information as the government desires. This gives it an enormous advantage over other means of collecting energy data.

The South African central statistics office does not currently collect very much energy data. Using it as the data collection arm of a national energy information system would, however, be advantageous.

Stats SA (Statistics South Africa, previously known as the Central Statistical Service (CSS)) is the South African central statistical office. It is regulated by the Statistics Act (SA, 1976) which empowers it to collect data. The confidentiality of returns is guaranteed under this act, which encourages companies to provide returns. This is an important consideration for both energy supply companies and consumers whose data can be very confidential.

Various censuses are carried out by Stats SA, using its comprehensive database of consumers to identify respondents to whom questionnaires are to be sent. Stats SA also has a good data collecting infrastructure which is invaluable. Linking a request for energy data to appropriate censuses would make gathering data fairly easy. It would also then be possible to obtain a better link between economic and energy data, something which is currently lacking in SA.

ii) Disadvantages

Despite the legal authority to collect data for government, not many central statistical offices have the ability to enforce returns. Thus requests for data may not be complied with, or returns may be very slow which reduces the value of the data. This applies to all data collection agencies and, in fact, central statistical offices can more easily overcome these problems than can other agencies. As the government arm for data collection, punitive legislation can be introduced to ensure compliance. At the same time, however, the enforcement of confidentiality must be secured.

The biggest disadvantage in using the central statistical office is not in their data collection ability - which is generally good. It lies in using this office for analysing and compiling energy data for dissemination. This is a specialised field of statistical work and employees not familiar with energy and the energy industry are likely to miss errors in returns. Specialised inputs are also

required in the compilation of questionnaires to ensure that the required data is collected in the best format and that all required data is included. Finally, few central statistics offices, including the South African, have the resources, expertise or mandate to run a dedicated energy statistics database, separate from their general national database.

The South African central statistics office suffers from most of the above disadvantages. Although the Statistics Act empowers the collection of data, enforcement is difficult and not pursued strongly. Slow returns are also a problem – the preliminary results of the 1988 Census of Manufacturing were only available in 1993. As regards the focus on pertinent energy data the Census of Manufacturing can again be an example – it only requires respondents to provide financial data pertaining to energy purchases and ignores volumes.

2.2.2 The use of sub-ministries

In some countries the energy ministry is divided into a number of sub-ministries. There may be a sub-ministry responsible for handling petroleum matters, another for coal and yet another for electricity. Instead of the energy ministry or central statistics office being responsible for energy data collection, each of these sub-ministries can be made responsible for collecting energy data relevant to its brief. This can be advantageous in terms of expertise. A central agency is, however, needed to compile the various data collections into one model before the information is truly valuable for analysis and policy purposes. At the least, the separate databases must be compatible.

In SA the Department of Minerals and Energy (DME) is responsible for managing national energy, minerals and mining matters. It has branches and directorates, which correspond roughly to sub-ministries. These are the Minerals Bureau, the Council for Geosciences and the Energy Branch. All

three collect data and create a number of databases, but not for a central information system.

i) Advantages

Sub-ministries are highly specialised and each should have a very good understanding of the structure of the energy industry it is concerned with. Expert knowledge also means that the sub-ministry's verification and correction of data can be good. Communication and good relationships between the sub-ministry and the energy industry are valuable in ensuring cooperation. This should occur, as staff members responsible for data (at the sub-ministry and the energy company) are specialists, understand each others problems and have close regular contact.

The Minerals Bureau, Energy Branch and Council for Geoscience are all very specialised and have the advantages of sub-ministries in their collection of data.

ii) Disadvantages

Lack of communication, or cohesive strategy, between the various sub-ministries can lead to unsatisfactory collection, standardisation and classification of data collected. Each sub-ministry may focus on the data it requires rather than on the overall goal of compatible data and a national system.

In South Africa there is no legislation, or central DME directive, harnessing the data collection of the directorates and branches to a single strategy. Thus, while each collects data, there is currently little cooperation between them regarding the uniformity and value of energy data.

A case in point is the Minerals Bureau and coal data. The Minerals Bureau is not particularly concerned with detailed sales data, but concentrates on

reserves, gross production and exports. Some sales data is collected but it is not available on a detailed end-use basis (See Table 2.1). While not of direct relevance to the Minerals Bureau's brief, more detailed sales information would be very valuable for incorporation into a national energy database or to the Energy Branch. More useful data could be obtained from the monthly questionnaire sent to the coal mines, provided the right questions were added and accurate responses obtained.

2.2.3 The use of a central body

The use of a central body operating under the direct control of the energy ministry is the third option identified. This body may be completely internal i.e. the central body itself being responsible for collecting, as well as managing and disseminating information. Or the body may utilise either the national statistics office or sub-ministries (or both), in the collection of data while the management and dissemination processes remain internal. A further alternative is to contract an independent institute or body (external to government) to do some or all of the work.

The main directive for a central body is that it should coordinate efforts towards a single national energy information system. A central body is more effective than any other means of achieving this aim.

i) Advantages

This is potentially the most promising system. With good internal structures, communication links between statisticians and policy makers can be made as short as possible, data collected can easily be standardised and duplication of effort eliminated. While it is important to ensure that there are sufficient suitably experienced personnel available to support maintenance of the data system, such experts are only required on the central body and not at each separate level i.e. within the central statistics office or each sub-ministry.

A central body that relies on data collected by the legally empowered national statistics office has the greatest chance of an adequate data supply. Sub-ministries can also provide specialised information and expertise. Inputs from the above are best coordinated by a central body, which is aware of all the parameters of the national system and the outputs required by policy makers.

A central body, directly answerable to the DME at top management level, can work well for SA. An external body is currently more likely to succeed than an internal one, as sufficient qualified staff within the DME are not available. The Institute for Energy Studies (IES) at the Rand Afrikaans University (RAU) successfully acted in this capacity from 1995 to 1998, compiling energy statistics on both a national and provincial basis (Cooper, 1998c).

ii) Disadvantages

A central body can become a liability if it merely duplicates work done by the central statistics office. Likewise, sub-ministries must either contribute to, or (at least) not duplicate the work of, the central body. The central body must have authority and control over data collection strategies and the systems for managing that data, or it will be ineffective.

One of the biggest disadvantages in SA is a lack of skilled energy analysts to operate such a system, especially within government.

A problem that can arise when using external organisations concerns the legal aspects of collecting data. Legislation needs to make provision for an outside organisation to collect data and also to specify that non-disclosure clauses are applicable to the outside organisation and its personnel. A second more serious concern, when using an external body, is that of continuity. A change from one to another external body can result in serious discontinuities and

inconsistencies in time series data, unless strict contractual and operational responsibilities are set out.

2.3 INTERNATIONAL - LEGISLATION AND STRUCTURE

In assessing and/or designing a national system for South Africa an understanding of other national and international systems is important. Compatibility with international systems is desirable in a national system, as this promotes data exchange and comparison. Valuable insights into problems and solutions can be gained from other national systems, and incorporated in the South African system. The legal and infrastructural elements of these other systems are as important as their content in this study. Information from seven countries, three international organisations, and South Africa, is considered in this chapter.

As the collection and compilation of national energy data should be a function of the State there is an implicit requirement for some form of controlling legislation. Some countries have specific, detailed legislation while others have very little or no legislation applicable to energy statistics. Yet other countries make use of generalised legislation to cover the collection of energy data. In some countries, legislation specifies the structure and identification of the body responsible for energy statistics. In designing this conceptual framework for an integrated, single access point national energy information system, clear legislative requirements for data collection are seen as necessary.

Structurally, energy information systems differ most importantly in the emphasis and boundaries of system outputs. The desired outputs not only determine the final answers gained from the system, but also govern what data needs to be collected and put into the system. The main reason most nations have a number of energy databases is that the originally defined scope was restricted to specific data. New information requirements mean

that there are data gaps and it is often easier to create a new database than to alter the old one. Apart from outputs, the structural differences in databases can also be caused by both hardware and software limitations. These can lead to incompatibilities and restrict the usefulness of outputs for further manipulation. A heritage of different institutions with different database systems using different file structures and referential data sets, which cannot be merged, is often the stumbling block to creating a single national system.

An important consideration for this thesis was the search for integrated, single access point national energy information systems. Huggett and Blomkamp (1987) studied energy data collection in six countries and found no integrated national systems. None of the eleven systems assessed in this chapter met the criteria either. All of the systems studied were of the stand-alone type and were not integrated into a single national system as proposed in this study.

2.3.1 A survey of seven countries

Information is, in general, more readily available from economically advanced countries, most of which have legislation governing the collection of energy data. The most complex national system is that of the United States of America (USA), operated by the Energy Information Administration (EIA). All other industrialised countries have some system, generally decreasing in complexity in less industrialised countries. To better evaluate the international situation, questionnaires were sent to the energy statistical offices of ten countries. The questions were of a qualitative nature and the questionnaire covered the following ground:

- Which governmental organisation is responsible for collecting and disseminating energy data?
- Is this organisation independent or is it part of a Ministry or Department?
- What legislation is in place to facilitate energy data collection?

- How is the data collected?
- What data is collected?
- Is the data stored in a single system or are multiple systems in operation?
- What outputs are produced?

The respondents were asked to provide samples of legislation, data collection forms and resulting reports.

Answers were obtained from seven countries, viz. the USA, UK, Canada, Australia, New Zealand, Taiwan and Japan. The content of the responses was in general poor, despite a repeat contact. Information was obtained via responses to the questionnaires and through personal visits to New Zealand, the USA, UK and Australia. The personal visits and interviews were not rigidly structured but were informal discussions on the energy data collection infrastructure, programmes, systems and outputs for the particular country. The systems in place, and their coverage, complexity and outputs varies widely between the different countries. The analyses for the countries given in the succeeding sections differs in detail depending on the amount of information obtained and on the complexity of the infrastructure and systems in place. The layout follows the logic in the questions, starting with the infrastructure and legislation, then evaluation of data systems, collection and outputs.

2.3.1.1 United States of America

The USA has a well-defined legal authority for the collection of energy data, created in 1974 under the Federal Energy Administration Act (USA, 1974). Two years later the Energy Conservation and Protection Act (USA, 1976) established an Office for Energy Information and Analysis. This office was to:

- operate a National Energy Information System,

- possess expertise in energy analysis and forecasting,
- be subject to performance audits,
- co-ordinate energy information activities with other Federal agencies,
- promptly provide energy information requested by any Congressional committee, and
- produce an annual report to Congress.

In 1977 the EIA was established as the single federal government authority for energy information (USA, 1977). Prior to the merging of all federal energy data collection functions under the umbrella of the EIA there were 238 individual energy data programs run by 23 executive departments and agencies (Department of Energy, 1993:6). The EIA was given independence from the rest of the Department of Energy as regards data collection, and incorporated all the mandates of the Office for Energy Information and Analysis. A Financial Reporting System to gather and disseminate energy industry financial data on an annual basis was also established. In 1992 the Energy Policy Act (USA, 1992) required the EIA to expand energy consumption surveys and indicated a number of other areas of concern where databases and studies were specified. These included alternatively-fuelled vehicles; greenhouse gas emissions; transportation rates and distribution patterns of coal, oil and natural gas; renewable sources of electricity generation; and foreign purchases of uranium.

There have also been a number of other Acts that have required the EIA to carry out specific studies. Some of these have been once-off requirements while others have required an annual or other periodic survey to be conducted.

Apart from the collection and dissemination of energy supply and demand data, the EIA also operates a number of models for energy policy formulation and evaluation, and future energy demand analysis. Two of the better known

models are the National Energy Modelling System (NEMS) and the Short-term Energy Model. Outputs from both of these models can be downloaded via the Internet (EIA, 1996a). The output from NEMS is published as the Annual Energy Outlook.

The EIA is governed by the Department of Energy Organisation Act of 1977 that created it as the single federal government authority for energy information. Apart from a major focus on oil and gas data, all other energy sources are covered by the EIA in various reports. The NEMS project was a major energy modelling project. The system was developed and is operated by the EIA (EIA, 1994a). Quadrennial surveys are done for manufacturing, commercial and domestic energy use. Legislation is effective and assists the EIA with data collection.

The EIA currently employs 374 permanent employees (DeMouy, 1999). External consultancies are used for market research. The EIA produces an impressive array of publications. In early 1996, a CD-ROM containing over a hundred of their publications was produced (EIA, 1996b). This has become a regular publication with one of the more recent issues containing more than 200 reports and databases. It also provides users who have Internet access direct connection to the latest available information on the selected topic contained on the EIA Internet site (EIA, 1998).

Some individual States within the USA have developed their own energy information systems. California is the State that has developed the most sophisticated system.

One concern is that the data systems for the various surveys are isolated and extraction of data for comparative purposes is very difficult. Estimation of, for example, energy efficiency indicators is a tedious manual process (King,

1997). The following three sections contain a general overview of the national consumption surveys and two of the Californian State systems.

i) National System

The EIA maintains the national data system that covers industrial buildings and processes, residential buildings and commercial buildings. The surveys are done quadrennially and are known as the Manufacturing Energy Consumption Survey (MECS), the Residential Energy Consumption Survey (RECS) and the Commercial Buildings Energy Consumption Survey (CBECS) respectively.

Coverage spans a host of technical and economic parameters on a regional and national level, including: demographic characteristics; energy prices; physical characteristics of residential, commercial and industrial buildings; industrial processes; appliances; fuel switching capabilities; on-site electricity generation; and purchases of electricity from non-utilities. These surveys also collect data on participation in energy management programs and the penetration of new energy efficiency technologies.

Users of the energy information system created from these three surveys include: the United States Congress; energy analysts throughout the Department of Energy and other Departments of the USA Executive Branch of government; independent energy researchers as well as those associated with industrial research and development programmes. International researchers and government staff interested in energy usage patterns and energy efficiency are also important users of the outputs.

This database set provides a national-level, comprehensive source of data that is systematically gathered and updated using statistically sound survey techniques. The objective of these information systems is to provide public and private stakeholders with reliable data spanning a wide range of

technical and economic factors from which research can be conducted and public policy established and assessed.

These EIA data systems are large scale efforts that represent a substantial commitment on the part of the U.S. Federal government to provide meaningful, across-the-board energy consumption data. The EIA uses both in-house staff along with contractor personnel to conduct the surveys, gather and validate the data, and maintain the information systems. Each of the surveys is conducted on a quadrennial basis with system maintenance and updates occurring continuously. On average the EIA devotes approximately 10 man-years of effort annually to the support of this system (King, 1997).

One objective of these databases, that is not currently served by the systems, is easy access to the data. The survey data from the MECS, CBECS, and RECS are stored in mainframe computers directly accessible only to EIA analysts. Other parties can obtain some data electronically through special request or via the Internet. All data are published as hardcopy in a series of reports prepared by EIA. Below are examples of analyses conducted by EIA using these survey data.

- The prime outputs from the surveys provide details and present statistics on energy consumption in the particular sector studied. Thus the analysis of the consumption of energy in the manufacturing sector is contained in the report titled "Manufacturing Consumption of Energy 1991" (EIA, 1994b). Similarly, the EIA published reports on Residential Energy Consumption (EIA, 1995d) and on commercial buildings (EIA, 1995a). Other reports compiled from information extracted from the survey relate to the characteristics of the buildings in the residential sector (EIA, 1995b:x-xvii) and in commercial buildings (EIA, 1997:vii-ix).

- An examination of the role of conservation in the choice of heating and cooling fuel across economic sectors. This analysis examined such factors as methods of weatherisation and its impact on heating and cooling costs by fuel and building type. Comparisons were made on the types of heating and cooling systems available on the market. Supporting cost tables were developed to aid in the selection of heating and cooling systems in each of three major climatic regions for a range of likely fuel prices and system efficiencies.

- The calculation of energy intensity in the manufacturing sector: The EIA calculates energy intensity in units of thousand Btu per constant dollar of value of shipments (EIA, 1995c:71). Data to perform this calculation reside in three databases/sources:

  - manufacturing energy consumption by two digit SIC from the MECS database maintained for the U.S. Department of Energy by the Bureau of the Census (U.S. Department of Commerce);

  - value of shipments from the database for the Annual Survey of Manufactures (ASM), which is maintained by the Bureau of the Census; and

  - industry-specific price indices from the Bureau of Economic Analysis to enable conversion of the value of shipments data to constant dollars.

  The set of industrial establishments responding to MECS are a subset of the establishments responding to ASM, thus ensuring a proper match of energy consumption to an establishment. The three types of data are imported into a spreadsheet model to calculate energy intensity (EIA, 1995c).

- Calculation of Energy Intensity in the Buildings Sector: EIA calculates energy intensity for commercial and residential structures in units of thousand Btu per square foot (EIA, 1995a:2). For the residential sector, additional measures include million Btu per building, household, or household member (EIA, 1995d:37). Energy intensities are calculated by EIA analysts for specific reports by importing data from the CBECS and RECS databases into spreadsheets.

From the above it is clear that the USA has enormous legislative and infrastructural support for the collection of national energy data. Much time and money is spent on comprehensive analyses and databases. Unfortunately there is not an integrated system operational at Federal level.

ii) California State Databases - Multi-Sector Model Database

This database is maintained by the California Energy Commission (CEC) (1999a) and covers all sectors. Data captured in the system includes general economic and demographic data (e.g. electricity use per person or per gross national product, end-use energy per person); electricity and fuel export, import, production and consumption; electricity and fuel prices; end-use energy intensity and fuel consumption; etc. The system also contains information on emission rates by energy sector, technology and economic activity. The source of each data element is cited.

The system is used by CEC staff, along with other analysts and decision makers examining energy efficiency policies, regulations, technologies and research agendas.

The system was designed to make both historical and forecasted energy information readily available from a central repository. Part of this objective was the requirement to design a system that could be used by non-computer

professionals. That objective was met through the design of a menu-driven database. The technical objective served by this database is to make pertinent information available to support energy sector analyses performed by Commission staff and allow commissioners to make informed decisions about the future direction of the state's energy policies and research activities.

iii) California State Appliance Efficiency Database and Energy Technology Office Bulletin Board System

This database is maintained by the CEC (1999b) and covers the Residential and Commercial sectors in the State. The database specifies the brand and appliance model number for each entry, followed by performance data. The database is updated every two weeks with a coverage of almost 65000 appliance items. Examples of performance data found in this database are:

- central air conditioning systems - capacity, seasonal energy efficiency ratio (SEER), and energy efficiency ratio (EER);
- heat pump - cooling capacity, SEER, EER, heating capacity, heating seasonal performance factor (HSPF), and coefficient of performance (COP); and
- gas furnace - fuel type, input Btu/hour, output Btu/hour, and annual fuel utilisation efficiency (AFUE).

This system was designed for, and is used by a diverse set of clients. Builders and developers use the system to as an aid to designing their projects and determining compliance with established energy efficiency standards. Electric and gas utilities use data from the system to design and manage demand side management (DSM) programs. Residential and commercial consumers also use the system to evaluate choices when making major appliance decisions.

The databases provide information on appliances and technology options for complying with California's strict energy conservation standards. It allows

parties involved in construction/development projects to analyse economic and social tradeoffs associated with the utilisation of energy efficiency technologies. This results in stakeholder participation in the decision process. Utilities are assisted in the design, development and implementation of DSM initiatives. Households and businesses are provided with access to performance data on virtually all appliances, allowing them to make informed choices.

The CEC has agreements with the Air Conditioning and Refrigeration Institute (ACRI) and the Gas Appliance Manufacturers Association (GAMA) to supply data on disk to the CEC. Data for other appliances is direct from manufacturers and is entered into the system by CEC staff.

The Appliance Efficiency Database is updated every two weeks, usually on Fridays. The database requires 1.5 full-time equivalent (FTE) person on an on-going basis to input and edit data. The information system contains data validation routines. A student is used to write programs to create web pages (0.5 FTE) (King, 1997).

The Appliance Efficiency Database contains information on appliance models with the highest energy efficiencies. For instance, it contains air conditioning systems with efficiencies that exceed California and U.S. national appliance efficiency standards by at least 10%. The appliance models in this database are a subset of those available by downloading the complete models listing from the Energy Technology Office's Bulletin Board System.

Efforts are underway to take the database from a minicomputer, where it is housed in an Oracle database, to a desktop computer (King, 1997).

2.3.1.2 United Kingdom

The United Kingdom (UK) does not have the same energy-specific legislation the USA has. There are two Acts which are applicable to the collection of energy data (White, 1992). These are the Statistics of Trade Act and the Electricity Act. The former defines the collection of trade statistics; provides for penalties for non-compliance; provides for confidentiality of returns and for penalties against government employees who do not adhere to the confidentiality clause. The Electricity Act came in force with the privatisation of the Central Electricity Generating Board (CEGB) and provision is made in the Act for statistics to be provided to the statistical authority (UK, 1989:69/70).

The Department of Trade and Industry (Energy Command) is responsible for the collection and dissemination of energy statistics. The focus of the work is on the collection and compilation of energy data, as well as energy modelling. There were 25 staff involved in energy statistics collection and analysis during 1994 (White, 1994). Apart from producing statistics, a model giving long-term energy trends is also operated. The focus of the modelling effort has moved towards estimating emissions - primarily CO_2 (Miller, 1992). The statistics produced are not as comprehensive as in the USA but are considered adequate for UK requirements.

General Standard Industrial Classification (SIC) groups are used for the collection of energy data. The output is presented as a monthly bulletin and as an annual report in softcover book form (Department of Trade and Industry, 1993). The system is not integrated as only energy data is included in the system.

2.3.1.3 Canada

Canada has legislation in the form of the Statistics Act (Canada, 1985) and Energy Monitoring Act (Canada, 1980) to monitor the energy industry. The main focus of the statistics department is on petroleum and gas supply and demand. Statistics Canada (the central statistics office) and Natural Resources Canada (NRCan) are the two official bodies responsible for energy statistics. (From information provided it can be deduced that NRCan has functions similar to those of the South African Minerals Bureau.) The two bodies liaise with each other to avoid duplication. Financial data on the petroleum industry is published on a quarterly basis. A loose-leaf compendium of energy statistics - Energy Statistics Handbook - with comprehensive energy and related data is published by Statistics Canada with monthly updates (Statistics Canada, 1994).

One feature of the Statistics Act (Section b (3)) is that outside contractors can be used for specific tasks provided they take a prescribed oath regarding, in particular, unlawful disclosure of proprietary information.

The Energy Efficiency Branch of NRCan has recently started work on a new system called the National Energy Use Database. This database system covers industry, residential buildings, commercial buildings, transportation and agriculture (Natural Resources Canada, 1999).

The data contained in the system are extensive, spanning technology-specific information across all sectors; end-use/energy consumption statistics; building characteristics and new construction projections; demographics; and economic parameters.

The database system is used by Government, private sector energy analysts, and academic researchers. To facilitate data analysis, NRCan has established

analysis centres at selected Canadian universities, with one centre for each sector. Each centre compiles and manages information for its sector. The Canadian commercial energy end-use database and analysis centre (CCEEDAC), for example, is located at the McMaster University in Hamilton, Ontario (CCEEDAC, 1999). Activities include: improving the consistency and comparability of different data sets; facilitating information exchange among stakeholders (government, sectors, academia); assisting NRCan in reviewing existing data; and advising NRCan on data collection initiatives.

The primary objective of the system is to expand and improve knowledge about energy consumption and efficiency at the end-use level in all economic sectors. This is, in particular, to support the reduction of greenhouse gas emissions through increased energy efficiency. Secondary objectives of the system are to provide government, industry, academia and the public with a comprehensive source of information on energy consumption, production, efficiency, and conservation. It also supports end-use modelling and forecasting efforts, linked to research and policy issues, being performed by various stakeholders.

The different centres analyse data from surveys managed by NRCan and provide survey design advice. Surveys include the Fuel Consumption Survey, the National Private Vehicle Use Survey, the Farm Energy Use Survey, the Survey of Household Energy Use, New Housing Survey, Homeowner Repair and Renovation Survey, and others.

In some ways this system is the closest to the integrated energy information system developed in this thesis, although data for different sectors is maintained at different locations. It was not possible to gain insight into the structure of referential data for the different surveys, or to determine if the same data set was used by each of the survey teams, nor were sample questionnaires obtained.

2.3.1.4 New Zealand

The Energy and Resources Division of the Ministry of Commerce is responsible for compiling energy statistics for New Zealand. The collection of statistics is divided between two units - one responsible for energy and the other for resources, with a number of publications being produced (Ministry of Commerce 1993, 1994a, 1994b). In 1995 the Energy Research and Information unit had five employees, two directly concerned with energy data (Edwards, 1995). Other outputs for this unit are related to energy forecasting, and liaison with the International Energy Agency (IEA). The Resource Information Unit is responsible for minerals information, with two employees working on statistics.

Sales data is collected in differing detail for different energy carriers. Coal, for example is collected for 6 end-use sectors, oil for 14 and electricity for 36 sectors. Energy data is available on a monthly basis from reports printed every six months. Energy balances are given for calendar years to end-March, end-June and end-December. The format of the energy balances is approximately that of the IEA. The system includes only energy data.

2.3.1.5 Japan

Japan does not have energy-specific legislation but has defined some energy data as designated statistics under the Statistics Law (Japan, 1947) and the Statistical Return Co-Ordination Law (Japan, 1952). These prescribe penalties for non-compliance; set out penalties; secure confidentiality of returns; and identify persons who can request these statistics. The responsibility for compiling energy statistics belongs to the Agency of Natural Resources and Energy (ANRE), which is part of the Ministry of International Trade and Industry (MITI).

The Energy Data and Modelling Centre (EDMC) and the Economic Institute of Japan publish a very useful booklet containing a comprehensive data set of both energy and economic data (EDMC, 1997), with energy data provided by MITI. No information was available to determine how the data was collected, on questionnaire formats nor on the structure of any system in place. No outputs other than those from EDMC were made available.

2.3.1.6 Australia

Official Australian energy statistics are collected under the Bureau of Statistics Act (Australia, 1975). Another body, the Australian Bureau of Agricultural and Resource Economics (ABARE) conducts a biennial Fuel and Energy Survey, but the collection of this data is done on a voluntary basis and is not covered by the Act (Hine, 1995).

Historical data and projections of future demand have been compiled and published by ABARE (ABARE, 1995). It could not be ascertained whether energy information is produced in other formats. No information was obtained on collection methodology, neither were questionnaire samples available to permit evaluation of the details of the data collection process. No information could be obtained on the structure of the system used.

2.3.1.7 Taiwan

Taiwan promulgated an Energy Management Law in 1980 (Li, Ong, Chou and Chen, 1992:194) in which an energy audit system was defined. Definitions of large power users are given and these companies are required to appoint at least one person as an energy manager, and to provide the government Energy Committee with energy information on an annual basis. The focus of the legislation was to provide government with a measure of energy

conservation practice and progress. One of the benefits of the legislation was that it enabled the government to compile annual energy statistics from the data provided. Data collected is limited to those users falling within the definition of large users.

Follow up work indicated the need for specially appointed consultants to assist concerns to comply with the requirements. Some statistics on the energy consumption for a number of industries was provided (Li et al, 1992:201-207). Following the Iraqi invasion of Kuwait in August 1990 the Taiwanese government increased tax benefits to energy users who upgraded to more energy efficient equipment. In the words of Li et al, (1992:209): "No quick and pronounced achievement except some scattering (sic) successful results was obtained. Even so, these results have proven that promotion of (sic) audit system is a (sic) effective and workable energy conservation policy."

2.3.2 International Energy Organisations

A complementary approach to studying individual national systems is to analyse the requirements of international organisations which collect energy statistics. Here the IEA and the UN are obvious examples. The World Energy Council (WEC) is also active in producing energy information for member countries. In view of the change in South Africa's position vis-à-vis the international community, it can be expected that South Africa will need to comply with data requests by these organisations in future. Close personal ties with statistical staff at the IEA assisted the researcher in gaining an understanding of the structure of this international organisation.

2.3.2.1 International Energy Agency

The IEA was formed after the 1973 oil crisis to act as an energy forum for the Organisation for Economic Cooperation and Development (OECD) countries.

Most, but not all, OECD countries are members of the IEA. The IEA is situated in Paris, France. The IEA produces energy statistics for both OECD countries and non-OECD countries. The basis for the data is information supplied by member countries and from numerous contacts in non-OECD countries. South Africa is not currently a member of the OECD.

Studying the questionnaires from the IEA (the same data is also sent to the UN) gives an indication of the information to be compiled for this organisation (IEA, 1998a). The IEA questionnaires call for electricity data for 18 end-use sectors; coal in 19 end-use sectors; gas in 20 end-use sectors and oil in 24 end-use sectors. In addition, the energy transformation sector is divided into a number of processes, and imports and exports are extensively covered. The sectoral disaggregation uses broad SIC groupings. For the transformation sector and that of energy imports/exports, far greater detail is required than is currently collected in SA.

The IEA has become an important provider of international energy information and the following three systems indicate the range of information provided by this agency.

i) IEA Energy Database

This database is the core of the IEA energy statistics programme. Data from all OECD countries is collected annually by way of questionnaires. Data for an increasing number of non-OECD countries is also being collected. In international terms the energy balance format devised by the IEA is now the de facto standard.

As noted, the IEA was founded primarily because of the effects of the oil crisis and most of the work done is still focussed on oil data. A book on IEA policies and actions (Scott, 1995:101-105) provides full details of IEA oil data requirements. Despite a brief to also focus on alternatives to oil (Scott,

1995:170–197), no specific details of other energy data requirements could be found.

The outputs of the IEA database are available in a series of three annual hard copy publications. Two of these are for the OECD countries (IEA, 1997a; IEA, 1997b) and one for non-OECD countries (IEA, 1998b). The two publications for OECD countries separate the statistical data (in common units of measurement for each fuel (IEA, 1997a)), from the energy balances (in the common unit of tons of oil equivalent (IEA, 1997b:ix)). The document for non-OECD countries includes both statistical data and energy balances. Restricted balances are given for many non-OECD countries where full details are unavailable.

In addition to the published hard copy references, the IEA also provides a diskette service for distributing the information electronically (IEA, 1998c). This service provides "...historical energy data extracted from four IEA/OECD databases..." (IEA, 1998c:6). From this it can be inferred that the energy data is actually stored in four separate databases, but that information can be combined for distribution purposes.

In the development of the conceptual data model, it is proposed that the IEA standard be used as the framework for the national system developed in this thesis. Cooper, (1994b:6/7) has previously suggested that the IEA classification system be adopted for South Africa for classifying energy data, as this system has become the de facto international standard.

ii) IEA Information System on Industrial Structures (ISIS) Energy Data Project

This system initially covers only the Manufacturing sector, but there are plans to extend to Transport, Residential, Commercial and Public Services, Agriculture, and Mining and Construction (IEA, 1999a).

In the fuels and electricity questionnaires of the IEA, the use of fuels in transport activities; for the production of other fuels (i.e. transformation); and for energy sectors' own consumption; are not allocated to a specific industry but are separately identified. The ISIS Energy Data Project adopts a different approach, by including fuels used in these activities within an industry into total energy use in that manufacturing industry. By way of example the production of coke by a company in the iron and steel industry is included in the transformation sector in the IEA Energy Database, but will be included in the iron and steel industry in the ISIS project. The three processes are listed below.

- Transformation is the production of other fuel forms from a fuel. It is any process which converts a primary form of energy to secondary (and further) transformation (e.g. coking coal to coke; crude oil to petroleum products; heavy fuel oil to electricity; PCI coal, coke oven coke, natural gas and oil to blast furnace gas or coke oven gas; fuel inputs to electricity/heat etc.).

- Own use refers to the primary and secondary energy consumed during transformation. It covers energy consumed for: heating; lighting; operation of all equipment used in the extraction process; traction; and distribution.

- Transportation relates to all movement of materials by pipeline, road, railway, air and internal navigation that is carried out directly by the industry under consideration.

The ISIS Energy Data Project covers 8 classes or types of fuel: solid fuels, LPG, distillate oils, residual fuel oil, gas, biomass fuels, steam, and electricity.

The database is intended for use by economists, policy analysts, market analysts, technology developers and persons wishing to maximise efficiency of energy consuming processes.

The goal of the programme is to collect data and establish a databank on energy consumption, (initially for the manufacturing industry sector), to be used for energy intensity studies. In addition, the collection of energy consumption data in a format that is fully consistent with OECD economic statistics provides a key tool to link economic and energy variables. By improving the understanding of where and how energy is used in the IEA member countries, the database will reveal opportunities for improving energy efficiency, as well as provide the information required to track progress on the energy efficiency front.

iii) CADDET Energy Efficiency Database

The CADDET database is maintained by the IEA Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) and covers all sectors (IEA, 1999b).

The CADDET system is a user-friendly database of demonstration projects containing more than 1600 records contributed by its 15 member countries (CADDET, 1999). This system provides abstracts on these international energy efficiency projects for the purposes of disseminating information on the use/usefulness of energy efficiency technologies. The project abstracts include: a general description, technical data, performance data, energy data, environmental data, and economic data. While efforts are made at consistency, not all types of data are addressed in each abstract.

This system is available world-wide via the Internet. It is used by researchers, project developers, market analysts and government decision makers.

The stated objective of the system is to broaden and improve the exchange of information on energy saving technologies that have been demonstrated in applications in industry, buildings, transportation, utilities, and agriculture. The system provides access to project abstracts as a means of sharing experiences, providing both positive and negative lessons learnt, and detailing benefits. The system provides a mechanism for sharing this information, and aids both government and industry in setting research and development priorities and directions.

2.3.2.2 The United Nations

The UN, through the United Nations Industrial Development Organisation (UNIDO), has developed two energy databases for providing specific information. The first of these is the UNIDO Industrial Statistics Database which covers the industrial sector by country (UNIDO, 1999a).

This database contains information on industrial activity for 89 countries. The following data are available at the three- and four-digit SIC level -- output, value added, wages and salaries, gross fixed capital formation, production indices, number of establishments and employment.

The system is accessed by a diverse set of users including government statistical offices, ministries of trade and industry, producers' associations, economists, researchers, industrialists and investors.

The public sector objectives of this system are: to provide information needed to conduct activities such as monitoring energy efficiency progress and changing conditions in the manufacturing sector or key industries; to assist in privatization activities or compliance with environmental regulations; the formulation of energy policies and/or regulations; and to satisfy the data requirements of multinational, or inter-country, studies. Private sector

objectives are: to provide organizations with meaningful information from which decisions can be made on research and development, and project investments; the monitoring of technology changes; and the collection of empirical evidence that can be developed to support policy positions. Emphasis has been placed on developing a set of data that are comparable and consistent, between countries and over time.

The second database is the UNIDO Industrial Development Abstracts Database. This contains over 21000 fully indexed abstracts of UNIDO documentation, including: descriptions of major studies and reports; technical assistance activities; expert working group proceedings; workshops, seminars and publications from 1965 to present (UNIDO, 1999b).

This second database is used primarily by project developers and market analysts. Public sector users include analysts examining technology market penetration and the direction and focus of research and development activities. The objectives served by the database are the provision of access to project abstracts as a means of sharing experience, providing lessons learnt, and detailing benefits. A mechanism for promoting and enhancing market penetration of promising technologies and setting the direction for research activities is also provided.

The UN publishes an annual compendium of international energy statistics, but not in the same detail as the IEA (UN, 1993).

2.3.2.3 World Energy Council

The World Energy Council (WEC) compiles energy data as part of its information activities. The prime publication is that of energy resources (WEC, 1998). This is published on a triennial basis, and is usually made available at the triennial World Energy Council Congress. This publication is

produced by the WEC using inputs from all member countries for all conventional fuels and with chapters on non-conventional and renewable energy sources. In all, the publication covers 16 different energy sources or groups of energy sources.

In the past the WEC also published a series of national energy profiles. This activity has been discontinued and the WEC is in the process of developing a Global Energy Information System (GEIS) (Nekhaev, 1999). The exact format of the outputs has yet to be finalised but it seems that the IEA balance format will be used. The initial intention is to include primarily energy consumption data for each country, together with a brief commentary on the general features of the energy economy, in the GEIS that will be available on the Internet (WEC, 1999).

The various geographic regions are tasked with developing their own systems. The design of the African Energy Information System (AEIS) is currently in progress, with the conceptual design being developed by Cooper (1999b), following the principles developed in this thesis.

2.4 SOUTH AFRICA - LEGISLATION AND STRUCTURE

The current South African energy data collection systems are described and assessed in this section. It must be noted that the author has, in the past, been responsible for compiling a comprehensive energy consumption database for the Department of Minerals and Energy (Cooper, 1994b; Cooper, 1998c). This data collection contract was, in part, a result of background research and proposals done and developed for this thesis.

2.4.1 Legislation

There is no legislation in SA specifically directed toward the collection of energy statistics. In fact, until 1993, the Petroleum Products Act (Act 120 of 1977 as amended) prohibited the publication of any information pertaining to petroleum products.

Legislation that affects energy data collection in SA includes the Statistics Act (SA, 1976) and the Electricity Act (SA, 1987). Section 3(1)(a) of the Statistics Act provides the legal mandate for Stats SA to collect statistics "...relating to economic, financial, demographic and social matters and any other matter determined by the Minister...". The Electricity Act (as amended) provided the Electricity Control Board (and provides its successor, the National Electricity Regulator (NER)) with the authority to collect information deemed necessary from electrical undertakings.

The Remuneration of Town Clerks Act (SA, 1984) is interesting although it was repealed in its entirety in 1996 (SA, 1996). The remuneration levels of Town Clerks were linked to a number of parameters. One of these was the number of electrical connections managed by the local authority (SA, 1986). From this it was inferred that an increase in the number of local authorities from which electricity sales data needs to be collected would rise. This is borne out from Eskom data on the numbers of bulk customers and the percentage of total sales to these customers. There was an increase from 486 customers taking 33,3% of sales in 1983 (Eskom, 1983:60) to 704 customers taking 45,1% of sales in 1991 (Eskom, 1992:22). Many of these local authorities are still unable to supply sufficiently detailed data, with a negative effect on the quality of electricity sales data.

In collecting data under the current system, problems are encountered with companies refusing to supply data, or simply ignoring requests for data, even

by governmental organisations like Stats SA. The situation is much worse for non-governmental institutions requesting data when doing research for the government, as data is supplied on the understanding that it will not be divulged or, more frequently, is not supplied at all. This needs to be addressed by developing the necessary legal mandate and creating the framework for the centralised collection, analysis and dissemination of energy data including mechanisms for enforcing compliance and guaranteeing confidentiality, whoever deals with the data.

Although countries like Japan, the UK and USA, amongst others, have legislation empowering them to collect data (and which set out penalties), the relevant energy statistics departments prefer voluntary co-operation rather than coercion. Confidentiality of returns is usually guaranteed with penalties imposed on persons who unlawfully disclose individual data. Also, should there be less than five (UK) or 20 (USA) responses in a particular category the data for that category is not published but is included in totals.

2.4.2 Structures

The structures of energy information systems in SA are discussed first by fuel sector and then by organisations involved in multi-fuel statistics. Finally a brief assessment and critique of the present SA situation and possible modifications is given.

The International Standard Industrial Classification (ISIC) system was produced by the International Standards Organisation. It is a hierarchical coding system used to classify economic activity, and a local adaptation of this system is generally used in catagorising economic activity (CSS, 1993). A listing of the system with codes is presented in Appendix A.

2.4.2.1 SA organisations involved in single fuel data compilation

These are narrow focus systems, where only one fuel, or a group of similar fuels, is included in the database.

i) Coal

Prior to 1989 the Transvaal Coal Owners Association (TCOA) collected local sales data categorised into broad SIC categories as indicated in Table 2.1 (Andrew, 1988). This valuable database was discontinued with the disbanding of the TCOA. Despite diligent search by the author, it is understood that this database was effectively discarded and no copies are available except for limited and aggregated data included in a modelling study (Cooper, 1988).

Stats SA collects limited data on coal prices as part of the series on retail and wholesale commodity prices. The Minerals Bureau collects coal production data, as well as sales data in a few sales categories, but not according to SIC. Data is collected on a monthly basis from coal mines for sales in terms of tonnage and value. The sales are categorised in Table 2.1.

ii) Electricity

Stats SA collects monthly generation data from producers. The results are presented monthly (CSS, 1998). Stats SA also undertakes a triennial Census of Electricity, Gas and Steam (CSS, 1992). The results are generally only made available 2 - 3 years after the census year. The data is not presented using the SIC classification system but in a few broad categories as given in Table 2.2.

Eskom produced a statistical yearbook on an annual basis from 1985 to 1996 (Eskom, 1997). Sales were presented in reasonable detail and there was some data classified by SIC. Publication of this valuable document was

discontinued for strategic reasons in 1996. Eskom customers are classified by SIC in the in-house sales database.

A large percentage of Eskom's sales are to municipalities and local authorities for redistribution. The situation as regards local authority electricity sales, whether self-generated or redistributed, is unfortunately inadequate. Municipalities are, virtually without exception, unable to give sales by more than 3 or 4 (non-SIC) customer categories. These are generally domestic, agricultural, commercial (small business users) and industrial. One problem with this system is that large commercial buildings are likely to be classified as industrial customers because of the size of their maximum demand and load factor patterns. Some municipalities cannot even provide data in these few categories.

A National Electricity Regulator (NER) was formed in 1995 to regulate the electricity industry (NER, 1999). Apart from its regulatory function, the NER also collects sales data from electricity distributors. A staff member indicated that the NER also has serious problems in collecting sales data from redistributors (du Plessis, 1996). Recent management upheavals have resulted in delays in producing more recent statistics.

Table 2.1: Coal sales categories - TCOA and Minerals Bureau

TCOA COAL SALES CATEGORIES	MINERALS BUREAU SALES CATEGORIES
Agriculture	
Fishing	Agriculture
Gold Mines	Brick and tile
Other Mines	Chemical
Sugar	Cement and hire
Food	Power generation
Beverages	Industries
Tobacco	Metallurgical
Textiles	Transport
Wearing apparel	Merchants and domestic
Leather	Gas
Wood	Synthetic fuels
Paper	Gold mines
Industrial Chemicals	Water
Other Chemicals	Other mines
Oil and coal products	
Rubber	
Cement	
Brick	
Glass	
Other non-metallic minerals	
Basic iron and steel	
Non-ferrous basic metals	
Metal products	
Machinery	
Electrical equipment	
Transport equipment	
Other industry	
Eskom	
Municipal electricity	
Other electricity	
Water	
Gas	
Rail Transport	
Personnel services	
State Tender Board	
Merchants (for resale)	

Table 2.2: Stats SA electricity census sales categories

Local Authorities own use :		Water
		Public lighting
		Own buildings
		Other purposes
Sales	:	Agriculture
		Gold and uranium mines
		Coal mines
		Other Mines
		Manufacturing
		Rand Water Board and other regional water
Corporations	:	Transnet
		Commerce, construction and other businesses
		Domestic use
		Street lighting
		Other purposes

iii) Oil

The publication of oil data was prohibited by the Petroleum Products Act of 1977 (SA, 1977) until the secrecy clause was rescinded in 1993. After the lifting of restrictions, Stats SA started publishing a monthly series of four data sheets in 1994. These were for the wholesale sales of fuels; sales of LPG; sales of lubricants; and sales of fuels to the agricultural sector. From January 1995, the four were consolidated into a single statistical release (CSS, 1995). Monthly sales data by product, magisterial district and customer category was provided to Stats SA by the oil industry. The customer categories were not according to SIC codings, but according to a system developed by the industry for their own use. The categories are given in Table 2.3. In 1997 Stats SA decided, for budgetary reasons, to discontinue this publication. The data can still be obtained from Caltex. Caltex acts as the 'secretary' company for the oil industry as far as sales data is concerned, and compiles aggregated data

from all the oil companies. Researchers, however, need to specifically request the data from Caltex.

Table 2.3: Oil sales categories as used by the oil industry

Retail Construction
General dealers
Farmers
Agricultural co-ops
General trade
Diamond mines
State Tender Board
Local automotive
Railways
Mining
Public Passenger Transport - Private
Public Passenger Transport - Local automotive
Road haulage
Local marine
Independent LPG marketers

iv) Gas

Coal gas, produced by Sasol Gas – a subsidiary of Sasol – is the only generally available pipeline gas in SA. Natural gas from the offshore gasfield, south of Mossel Bay, is used at the Mossgas plant to produce liquid fuels and chemicals.

Most of the coal gas sold in South Africa is sold by Sasol Gas. Sasol Gas has good records of sales and began classifying customers by broad SIC sectors during 1994 after discussions with the author.

About 10% of Sasol Gas sales are to Metro Gas, the gas network of the old Johannesburg City Council, which acts as a redistributor within the old

boundaries of Johannesburg. The categories which Metro Gas can identify are domestic, commercial and industrial. This data is not generally available.

2.4.2.2 SA organisations involved in multi-fuel data compilation

There are a number of organisations that compile energy data not confined to a single fuel but covering multi-fuel information.

i) Department of Minerals and Energy

During the decade following the publication of the White Paper in 1986, there were only two official publications containing energy data for the country. These were the 1990 publication of Energy Statistics Volume 1, by the National Energy Council (NEC, 1990), and the 1995 publication of Energy Statistics Volume 2, by the Department of Mineral and Energy Affairs (DMEA, 1995). This data was not classified by SIC and, because of legislative restrictions, petroleum data was removed from distribution copies. An estimate was made of biomass consumption.

Energy data was informally revised in 1996 (Cooper, 1996) and a formal publication with updated information, including petroleum numbers, complying with the IEA energy balance format was produced in 1999 (Cooper, 1999a).

ii) Statistics South Africa

Apart from the carrier specific statistics already mentioned, Stats SA also collects financial data concerning energy use in the triennial Census of Manufacturing. The most recent census for which data is available is 1993, which was published during 1997. The data, as published, is divided into two categories - electricity and all other energy carriers. It is possible that statistics for other energy carriers will be included in the future.

iii) Institute for Energy Studies

The Institute for Energy Studies (IES) at the Rand Afrikaans University (RAU) has done work on energy consumption patterns since 1985. Data on commercial energy consumption for 11 final sectors was collected annually and made available, as part of a modelling project, to a number of institutions which supported the project. This data is the most comprehensive commercial energy data available in time series form and covered a period of twenty years from 1972 to 1991 (Cooper & Kotzé, 1992).

In 1990 the IES commenced a project to collect data in 39 economic sectors, by geographical region and by end-use. Data for 1989, 1990, 1991, 1992 and 1993 were collected during the course of this project. This data related only to commercial energy, although the use of biomass by the industrial sector was included (Cooper, 1994a:8,10). In 1995, the IES commenced an expanded project for the DME to produce energy balances for SA in the IEA format (Cooper, 1998c; Cooper, 1999a:8,11). This project was concluded in 1998. Outputs are available from the DME.

iv) Energy Research Institute

The Energy Research Institute (ERI) at Cape Town University (UCT), has investigated energy demand in the industrial sector. A three volume study on energy utilisation was conducted by ERI for the Department of Planning and the Environment (1978). An update for five sectors was completed in 1984 (Huggett, 1984). A few other data or energy audit projects have been executed for the DME but these were very much ad hoc projects.

v) Energy for Development Research Centre

The use of non-commercial forms of energy, particularly in the domestic and agricultural sector, also needs to be addressed when compiling energy statistics. The Energy for Development Research Centre (EDRC) at UCT has done work on the Third World domestic sector but there needs to be more

quantitative data generated on the use of non-commercial energy carriers (Afrane-Okese, 1998).

vi) Energy supply companies

Individual energy companies generally compile energy consumption databases aimed mainly at market intelligence. Such databases are usually treated as strictly confidential. Companies also have customer sales databases that are an invaluable source of information but these again are treated as confidential. Provided that full co-operation of the energy companies can be obtained, the incorporation of data from these sales databases will be of crucial importance in laying the foundation for the proposed national energy data system.

2.4.2.3 Evaluation of the current data systems

There are both strengths and weaknesses inherent in the current data collection systems in SA. Unfortunately the weaknesses outweigh the strengths.

One strength is that a few individuals have, with limited means and no legislative backing, attempted to maintain comprehensive databases. Support from isolated energy companies kept these attempts alive. The energy balance produced by the IES, for example, is comprehensive. As mentioned previously most of the energy companies keep some form of market intelligence database and do have their own sales databases. These sales databases could be put to excellent use in compiling a comprehensive consumption database for the country. The petroleum industry, for example, did in the past provide data on petroleum product sales down to the magisterial district spatial dimension to Stats SA, and will provide this data on request to researchers.

The major weakness in the system is the lack of a central body, with legislative backing, directing the collection of energy data and ensuring that the data, models and policy link is operating effectively. Furthermore the resources invested are inadequate to meet the requirements of a comprehensive and accurate information system. Despite the lack of funds and other resources, there is unfortunately a certain amount of duplication of effort.

As noted above, there are databases for individual fuels, and databases for two or more fuels. But little attempt was made to standardise databases or to incorporate the contents, not only of energy data, but also of economic and other data, into a single integrated information system. There is limited correlation of referential data classification sets between these separate systems, and few conform to international standards.

The data collection project conducted by the IES between 1990 and 1994 showed that there was a lack of awareness of energy among many manufacturing concerns. A problem with many municipal electricity accounts was also noted in that the energy usage was often not clearly indicated. This particular project was done as a consumer sample survey and as a supplier survey. There were a number of important considerations which became apparent during the course of the study and which provided useful insight into more effective methods of data collection (Cooper, 1993a).

There is no fully integrated system, as developed in this thesis, in place in SA. A start has been made with the IES system to produce energy balances and time series tables developed for the DME (Cooper, 1998c).

However, any database starts with the collection process and once legislation is in place to allow unimpeded collection, the collection program itself must be considered. Recent unreported research done by the author at the IES

indicated that data collection should be separated into two definite data collection programmes, these being supply side and demand side programmes. These are briefly introduced here while a more critical analysis will be done in developing the conceptual model in the following chapter.

i) Supply side data

It is proposed that supply side data be collected on an annual basis from energy suppliers. This must take the form of sales data on a geographical basis, using a standard sectoral (client) classification (preferably SIC). In general the supply side data available at a macro level has four problem areas. These problems involve insufficient disaggregation and non-standard classification, which will need to be addressed as follows:

- a breakdown of local authority electricity sales needs to be classified by SIC;
- a breakdown of oil sales by SIC, the analysis and capture of crude oil flow data, and analysis and capture of export and import data for petroleum products is required;
- coal sales data requires a complete overhaul as far as sectoral and spatial classification is concerned; and
- more detailed analysis of biomass utilisation needs to be made with the aim of producing better aggregated data for different spatial dimensions.

The co-operation of Stats SA should be enlisted to assist energy suppliers in classifying manufacturing concerns by location and SIC codes. This will facilitate the disaggregation of energy sales data with all energy suppliers using the same classification system. The benefits of standardisation are obvious. It must be pointed out that enlisting the co-operation of suppliers and helping them to classify their customers is likely to be crucial to the success of any integrated system.

ii) Demand side data

The demand side program need not be carried out annually, as triennial (or even quadrennial) surveys should be sufficient to provide adequate data. This means that the triennial manufacturing censuses carried out by Stats SA could be used as a questionnaire vehicle. Questions relating to end-use and volume, in particular, would need to be added.

On the demand side the main aim should be to identify the end-use for which energy is utilised and to identify changing patterns of energy use. A major problem is that very few concerns measure how energy is used. The information given will, in most cases, be estimates - which can be very inaccurate. Volumes are much easier for most users to ascertain. End-use and equipment details are very important for detailed studies on energy efficiencies.

In principal there should be no objection to Stats SA including volume data in the Census of Manufacturing questionnaire. The inclusion of an end-use matrix will, however, require comprehensive motivation. The use of external consultants could be considered, provided the Statistics Act is applicable to their relationship with Stats SA and their treatment of data.

2.5 SYNTHESIS

There are many different databases in operation throughout the world. The vast majority are stand-alone systems with little integration, yet the reality is that many of the outputs are linked in the real world. Consider some of the problems of non-integrated systems. Often more than one database must be used to extract the desired information for a report or analysis. In some cases, computerised synthesis is impossible because different classification standards are used or there are hardware and software incompatibilities. In

many cases manual extraction and manipulation of data must occur, often requiring the recapture of data. In many countries, including SA, all relevant data is not collected, nor is all the data which is collected compiled into a national database.

In terms of staff utilisation, man- and equipment hours and other costs, all of the above is inefficient and wasteful. In terms of the information obtained from the various systems, gaps and losses in the data are unavoidable and compromise information quality. Policy makers need comprehensive information and often require new analyses or models to be run. When inflexible and/or incomplete databases are used to do this, the quality of the final policy is likely to be compromised.

It can be deduced that a system that enables analysts to extract all the required information through a single point, in a format which has already been referenced to a single standard, should be more desirable than one where this is not possible. DeMouy (1998) of the EIA indicated that this would indeed be the case. The challenge is to order and reference all data captured into the system in a uniform manner, ie. all data must be referenced to a standard referential framework. How this can be accomplished is detailed in Chapter 3. Some of the desirable outcomes would be:

- less data would need to be captured as duplication will be avoided
- a reduction in data capture errors as data need only be verified at one point of capture
- data capture staff would be centralised and numbers could be reduced
- policy analysts would have more time available for analyses rather than having to first ensure that data from different sources was referentially compatible

International organisations are currently attempting to promote certain standards pertaining to what, how much and in what form data should be

collected. These efforts provide useful guidelines for developing the referential framework for an integrated information system.

The policy maker needs to appreciate that enabling legislation must be in place to facilitate data collection efforts. Such legislation must make provision for: who is to be ultimately responsible for collecting data and disseminating the analysed information; the use of external bodies where required; punitive action against tardy or non-providers of data; and the enforceable confidentiality of data received.

A centralised structure or agency, staffed with skilled analysts is the most efficient way to provide a national system. Such an agency should define and manage data collection for all energy sources and ensure that the classification of all data collected is compatible with national and international standards and needs.

The challenge is to create a framework within which data can be linked to a standardised referential frame, enabling policy makers, analysts, industry planners and investors to extract relevant information about all facets of the national energy economy through a single user interface. The focus of this thesis is to develop that framework and the concomitant data and conceptual design model. This will be done in the next chapter.

CHAPTER 3: CONCEPTUAL FRAMEWORK

3.1 INTRODUCTION

This chapter sets out a broad description and analysis of the conceptual design for an integrated national energy information system. The topic and proposed solution are complex and there are a number of valid approaches or starting points. A top-down approach was selected as providing the most logical modelling of the conceptual design. The complex nature of both the energy industry and any analysis involving energy, resulted in a multi-level data model. The models of the system, developed in this chapter, provide the framework for the more detailed data analysis in Chapter 4.

Starting from the broadest overview, this chapter initially considers the integrated national energy information system as a data flow model. In this approach the three stages, collection, processing and dissemination, of data flow are described.

The second overview, the system model, details the content of the system. The system content consists of the areas created within the system during the design process. These areas are integral, defining what the system will do, how it will do this, and what data will be contained in the system. The system model has two divisions, the first containing the referential data sets and management functions, and the second containing the data storage modules. The first division thus has the central control function for the system, while the second captures and structures the collected data.

For the system developed in this thesis, successful implementation depends on the rigid application of a single referential data set with four dimensions - fuel type, economic sector, spatial location, and time. These four dimensions classify all captured data, ensuring that any data can be accessed and

compared using a standard referential framework. As far as can be ascertained, no other energy information system in the world utilises a single referential data set. The value of standardised outputs in the formulation of policy is incalculable. In the USA, for example, the EIA must perform time-consuming manual extractions and re-computations to produce a report from more than one database, where different referential data sets are used.

Moving to a more detailed conceptualisation of the integrated national energy information system, the third section of this chapter models the energy flow through the economy. This is referenced to the four referential dimensions. The energy flow model shows the importance of the economic sector dimension and leads to the most detailed model, that of final consumption. The final consumption model was developed to assess the need for separate programmes to collect energy consumption data from both supply and demand side sources.

3.2 DATA FLOW MODEL

The process of data flow starts with the collection, initial analysis and capture of raw data. The data is verified and validated before electronic incorporation into the data tables. This stage is described as the ***collection*** stage. The data is stored in the central system, which incorporates maintenance, management and processing functions. This stage has been designated as the ***processing*** stage. Access filters and system protocols determine what information can be extracted from the system, and by whom. The final stage is that of extraction and dissemination, designated the ***dissemination*** stage.

This data flow sequence, with the main related functions, is presented graphically in Figure 3.1. This is the highest, or broadest, descriptive level of the proposed system. It is a further development of design work done for a

national energy efficiency information system (Cooper, 1998b:40) for the DME.

While the data flow is from collection to dissemination, as explained above, the system operates in more than one direction. The starting point for the system design is in fact the desired outputs. The processing stage of the data flow model must be designed to capture and maintain data from the collection stage in sufficient detail to permit extraction of the desired outputs. This in turn determines and defines the data to be collected. Assessment of data flow and content structures must be possible at any of the three stages. The system must be designed so that outputs can be modified or improved upon should this be necessary.

3.2.1 Collection stage

There are essentially three sources from which data can be obtained in the collection stage. The first source is extant databases. While none of the existing databases is a complete system, many contain vital information that is unobtainable elsewhere. Their inclusion in the integrated system is necessary for full utilisation of their data. Examples of important extant databases are the customer sales databases, or predefined aggregation of data therein, for energy suppliers. If the data is in an electronic format, it should be possible to import the data directly into the new system. Where direct import is not possible, it may be possible to convert the existing data into a different format that can be imported.

The second source of data is surveys and censuses. Some extant historical sources contain valuable information and should be included. Other surveys and censuses can be specially commissioned, or run on a regular schedule. For example, Stats SA has historical data, and can carry out future censuses. Data from these sources will, in general, need to be analysed, classified and

captured into the system, implying the need for analysts and data capture personnel.

The third source is that of textual information, such as project reports or legislation. This information must be coded for easy and logical access and extraction, using the referential data set where appropriate, and using descriptive keywords. Textual data can be scanned in, if only hard copy is available, or imported in electronic format if the format is compatible.

Data verification is a vital component of the entire system. The raw data obtained from all sources must be checked for errors and false premises. Data capture errors must be identified and corrective action taken. Double counting and duplication of data must also be eliminated. If verification and validation is ignored, then the integrity of the entire database is suspect. Spitzer and Evans (1997:78) quote Al Shugart, CEO and chairman of Seagate Technology, as suggesting "...that data integrity - determining whether data are correct - is the single most important element in making successful decisions." The data verification process is the interface between the collection stage and the processing stage.

3.2.2 Processing stage

The second stage of data flow within the system is that of data storage and processing. After validation the data is captured into the main database modules. These are contained in the 'Energy Information System' block in the processing stage, as shown in Figure 3.1. Regular data maintenance and processing activities take place during this stage. Data may be added, updated or revised. Data tables may need to be modified; or new tables added; or new relationships between tables created. The interfaces that channel data flow between the processing stage and the dissemination stage, are the access filters and system protocols. These determine the type of

queries that can be answered and their format. These interfaces also determine who may access the system for information and at what level.

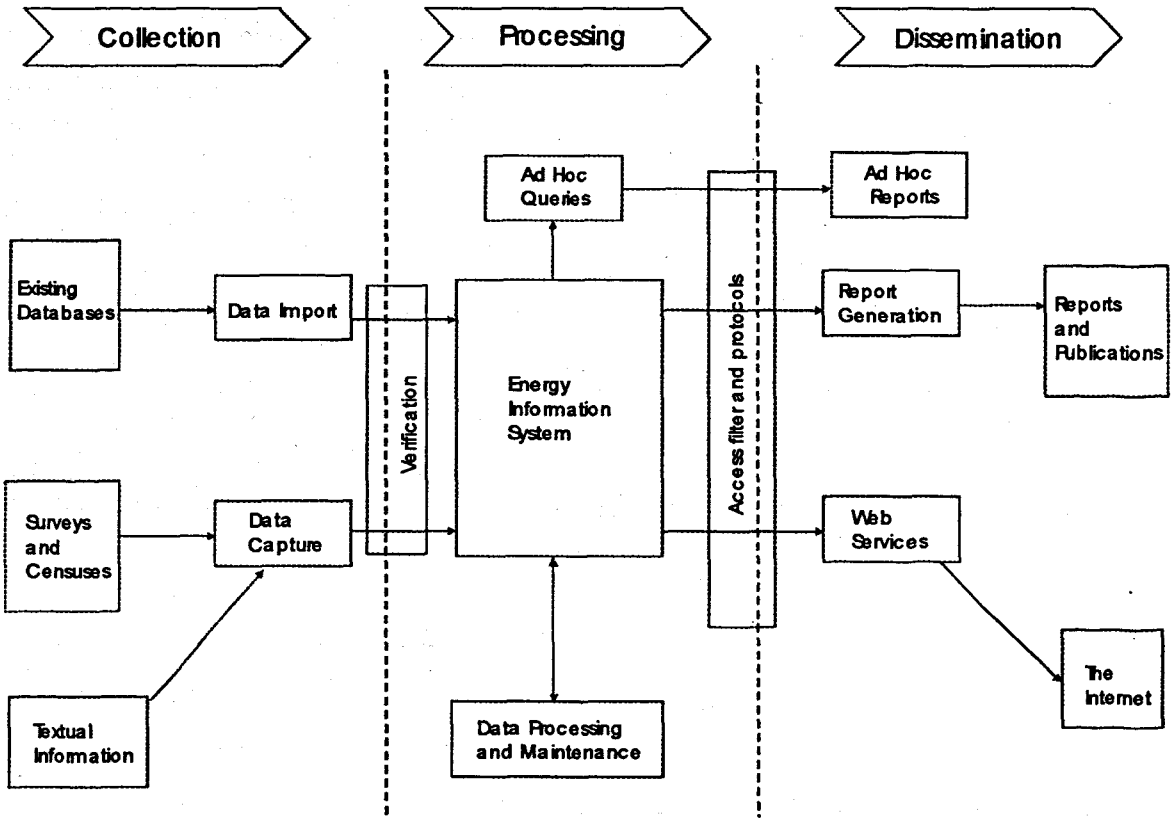


Figure 3.1 Data flow model diagram

3.1.3 Dissemination stage

The third data flow stage is that of information dissemination. Outputs can be made available via a fixed report generator, or in the form of ad hoc reports or queries. They may be available in hard copy, or electronically through standard format files or Internet services. Fixed reports are generated as a result of hard-coded programming modules that run predetermined queries on the data using variable search parameters set by the user. As a result regular reports and publications are produced and disseminated, for example an annual national energy balance will be generated for dissemination to specified users. Ad hoc queries would result in 'one-off' reports and are only possible to the extent that flexibility has been designed into the system. Some

outputs require information derived from data in more than one database table or module, for example efficiency information is derived from energy input and economic output data. The system must be designed for the greatest possible flexibility in outputs yet provide an integrated, single access point to data.

3.3 SYSTEM MODEL

The desired outputs from the system, plus the central function programs, determine the system content, and provide the framework for developing the system model. There are two divisions in the model, which is presented diagrammatically in Figure 3.2, and discussed in detail in sections 3.3.1 and 3.3.2.

The first division contains the central control functions of the system. These are the referential and management functions that must be in place to form the administrative and maintenance nucleus for system operation. These functions need to be designed to permit the seamless incorporation of additional data tables whenever resources and operational requirements permit and dictate. They must provide the flexibility to handle current and future (both expected and unforeseen) output requirements. This will allow the system (including the central control functions) to be expanded or altered, as and when required. There are four modules within this division of the system model, and they are included in Table 3.1.

The second division of the system model contains 19 modules - data tables and areas. These are the structures that capture the data flowing into the system and organise that data as prescribed by the central control functions. The system being designed here is intended primarily for energy policy support measures, so information requirements identified by the government are important. Required output information determines what modules should

be included. The White Paper on Energy Policy contained a section on information needs and this section is quoted in full here (DME, 1998:75/76).

"To facilitate integrated energy planning a database needs to be maintained covering at least the following areas:

- energy resources;
- energy production from indigenous resources (mining, renewables, oil and gas);
- international energy trade (imports and exports);
- energy transformation (production of liquid fuels and electricity from other sources);
- storage, transport and distribution of energy;
- national energy trade (wholesale and retail);
- investment in plant and infrastructure associated with the above areas;
- disaggregated energy usage, expressed in energy and cost terms;
- energy efficiency;
- energy related environmental emissions;
- average sectoral energy prices and taxes;
- institutions linked to all the above areas; and
- similar data from regional and international sources."

This list and one generated as part of the user requirement specification for an energy efficiency database for the DME (Cooper 1998b:63-71), were adapted to include additional valid modules for which information should be available (and therefor data collected) in an integrated energy information system. The adapted list is given in Table 3.1.

Table 3.1: System model components

Central control functions

- Referential data sets
- Data management
- Data manipulation and extraction
- Network and Internet connectivity

Data tables and areas

- Resource data
- Energy data
- Economic, demographic and operational data
- Efficiency data
- Price data
- Environmental data
- Project data
- Infrastructure data
- Contacts data
- Specifications and standards
- Bibliographic data
- Case studies
- International data links
- Products and equipment data
- Modelling modules
- Training and education
- Policies
- Rural energy
- Geopolitical data

These two divisions are presented diagrammatically in Figure 3.2 and are discussed in depth in the sections that follow. Note that the interrelationships given in the figure are incomplete. The entire system is far more complex than depicted, as the different modules are all related to each other and only some of the principal and obvious linkages are indicated. The full set of linkages will be analysed in the more detailed data analysis developed in Chapter 4.

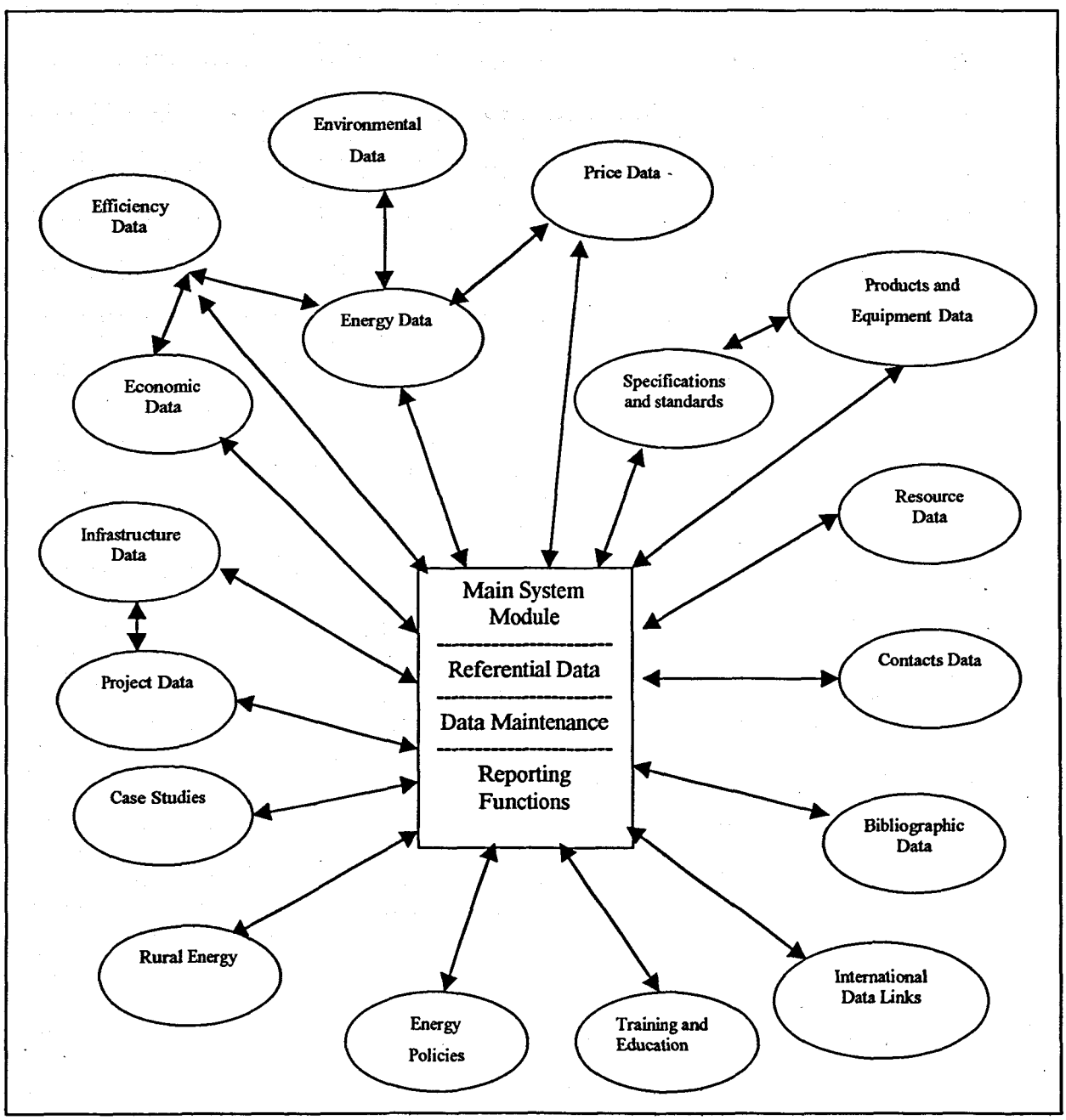


Figure 3.2: Comprehensive energy information system model

3.3.1 Central control functions

The central control functions of the system fulfil an administrative role, and must be operational before any other functions are implemented. This division includes those programming modules and housekeeping systems required to ensure system operation. There are four essential modules, all of a functional nature. These are: referential data sets; data management and maintenance functions; data manipulation, extraction and reporting functions; and communication functions via a network or the Internet.

3.3.1.1 Referential data set module

The referential data set is a special group of data tables in the first division of the system model. They contain the codes and descriptions for the referential framework used within the system. These classify the statistical and textual data captured in the data tables and areas in the second division of the system model. The referential data set is the key for accessing and querying all other data in the system. There are four dimensions that need to be incorporated into the referential data set. These dimensions are fuel type, economic sector, spatial location and time unit.

Because this information system is concerned with data on energy, the primary dimension is fuel. Once the fuel data is categorised, the use of each fuel needs to be further classified by economic sector, by time period and by spatial dimension. Different levels of aggregation within each referential dimension are required. For example, information is required for each provincial spatial unit but aggregation to the entire country is also essential. Similarly time periods could be for months, quarters or years.

All data captured in the second division can be referenced to one or more of these referential dimensions. For example, data captured in the 'resource data

table' can be related to a specific geographic unit, a specific time period, and a specific fuel. Some data may be referenced to all of the dimensions. The referential data set also controls and defines the framework for information extraction. Standardisation of the reference frame is critical to the successful implementation of the system. The four dimensions of the referential data set are detailed in the sections that follow.

(i) Fuels dimension of the referential data set

The definitions for fuels as set out by the IEA (1998a) are the basis for this dimension. A limited number of fuels are not individually identified in the IEA data set. In an African context, charcoal and dung should be specified as they are of import in some areas. They have been added at the appropriate point.

The IEA fuel classification is tabulated below in Table 3.2. The fuels are divided into a number of distinct groupings and the table indicates the hierarchy as well as all the different fuel elements as classified by the IEA. A full set of fuel definitions is included in Appendix B.

(ii) Economic sector dimension of the referential data set

The use of the ISIC or its local adaptation (Appendix A gives the SA version) will provide the required referential framework for this module. Two levels of aggregation for this sectoral classification system are applicable, one for data obtained from supply side sources and one for demand side sources. The supply side classification is, in effect, an aggregated subset of the more detailed (disaggregated) demand side classification.

The IEA has developed a framework (shown in Table 3.3) of 24 final consuming sectors, which correspond largely to the major divisions of ISIC. This is the framework for the annual energy balance and uses an aggregated

Table 3.2: Referential data set – fuels dimension

- Coal
  - Hard coal
    - Coking coal
    - Bituminous coal
      - Anthracite
      - Bituminous coal
    - Sub-bituminous coal
  - Brown coal
    - Lignite
    - Peat
- Patent fuel
- Coke oven coke
- Gas coke
- BKB
- Gas works gas
- Coke oven gas
- Blast furnace gas
- Oxygen steel furnace gas
- Commercial renewables and waste
  - Solid biomass and animal products
    - Wood
    - Charcoal
    - Other vegetal materials
    - Black liquor
    - Dung
    - Other (specify)
  - Gases from biomass
    - Landfill biogas
    - Sludge gas
    - Other biogas
  - Industrial waste
  - Municipal solid waste
- Natural gas
- Crude oil, NGL & feedstocks
  - Crude oil
  - Natural gas liquids
  - Feedstocks
  - Additives
  - Other hydrocarbons (syncrude)
- Petroleum products
  - Refinery gas
  - Ethane
  - LPG
  - Naphtha
  - Motor Gasoline
    - Leaded
    - Unleaded
  - Aviation gasoline
  - Jet fuel
    - Gasoline type
    - Kerosene type
  - Other kerosenes
    - Illuminating kerosene
    - Power kerosene
  - Diesel
    - Automotive
    - Furnace oil (LFO)
  - Residual fuels
    - Low sulphur (S<1%)
    - High sulphur (S>1%)
  - White spirits
  - Lubricants
  - Bitumen
  - Paraffin waxes
  - Petroleum coke
  - Other petroleum products
- Nuclear (primary energy)
- Hydro (primary energy)
- Geothermal
- Solar
- Tide, wave & ocean
- Wind
- Electricity (secondary energy)
- Heat

Table 3.3: Referential data set – economic sectors

- Indigenous production
- Imports
- Exports
- International marine bunkers
- Stock changes

Domestic supply
- Transfers

Transformation sector
- Public electricity plant
- Autoproducer electricity plant
- Public CHP plant
- Autoproducer CHP plant
- Public heat plant
- Autoproducer heat plant
- Heat pumps
- Electric boilers
- Patent fuel plants
- Coke ovens
- Gas works
- For blast furnace gas
- Petrochemical industry
- For BKB
- Oil refineries
- Liquefaction
- Transformation not specified

Energy sector
- Coal mines
- Oil and gas extraction
- Patent fuel plants
- Coke ovens
- Gas works
- BKB
- Oil refineries
- Own use in electricity, CHP and heat plants
- Used for pumped storage
- Nuclear industry
- Energy sector not specified
- Distribution losses

Final consumption
- Industry sector
  - Iron and steel
  - Chemical and petrochemical
  - Non-ferrous metals
  - Non-metallic minerals
  - Transport equipment
  - Machinery
  - Mining and quarrying
  - Food and tobacco
  - Paper, pulp and print
  - Wood and wood products
  - Construction
  - Textiles and leather
  - Industry not specified

Transport sector
- International civil aviation
- Domestic air transport
- Road
- Rail
- Pipeline transport
- Internal navigation
- Transport not specified

Other sectors
- Agriculture
- Commerce and public services
- Residential
- Other not specified

Non-energy use
- Feedstock use in petrochemical sector

level of the SIC. Other data captured will use the full detailed SIC classification as the referential data set.

It should be remembered that it is possible to aggregate disaggregated information but impossible to disaggregate aggregated information. For this reason, the most complete SIC should be used as the referential set wherever possible.

(iii) Spatial dimension of the referential data set

The spatial dimension is the third in the referential data set. This referential dimension contains the hierarchical system for defining location within the country. There is however no restriction limiting the spatial dimension to only one country and it is feasible to extend the system to include all countries on the African continent or, if required, the world. This conceptual design is limited to South Africa but the addition of a country code to the referential set would expand it when needed.

A top-down approach is used to define the spatial dimension as shown in Table 3.4. The structure can allow for site co-ordinates displaying an exact location, if use is made of a Geographic Information System (GIS). Some data lends itself to a GIS linkage. These will be identified at the appropriate sections.

Table 3.4: Referential data set - spatial dimension

Country
Province
Magisterial District
Suburb/Township
Site - co-ordinates

(iv) Time unit dimension of the referential data set

The final dimension defines periodicity, capturing data for different time units. The calendar year will be the main measure used for defining time, but there are some data where time periods of less than a calendar year are essential. An example is petroleum product pricing, where adjustments are made on a monthly basis. In addition there are some data which is available on a daily basis. The exchange rate and crude oil price are two examples. The system must be sufficiently flexible to make provision for different time spans where required. The hierarchy is tabulated in Table 3.5.

Table 3.5: Referential data set – time dimension

Year
Quarter
Month
Day

3.3.1.2 Data management module

This area of the central control function contains all the system elements required to capture and maintain the data in the system. Development of this module is a task for systems analysts and programmers, and no further details are provided in this study.

3.3.1.3 Data manipulation and extraction module

System elements that permit users to extract information are essential. This module will allow users to query the system using both fixed and ad hoc output formats. The extraction of information for incorporation into selected report-writing programs is also a function of this module. Again the

necessary development is a programming function. The definition of outputs is, however, part of this study and will be detailed in Chapter 6.

3.3.1.4 Network and Internet connectivity module

Connectivity to a network accessible to all users, and access through the Internet, is essential to provide all users access to the most up-to-date information included in the system. This module is required to facilitate such access. Information published on the Internet will be extracted from the system and then converted to the required format for electronic dissemination.

The Internet, and more specifically the World Wide Web, is becoming more important as a medium for information dissemination. While most of the analytical work would probably not be conducted using the Internet, it does make sense to disseminate many of the completed analyses and reports in this way. There is an economic benefit in that the costs of printing and storing of completed reports can be reduced. It would also be possible to permit users to directly access the individual modules via the Internet.

3.3.2 Data modules division

The modules in the second division contain those structures that capture and store data in the system. Each module may include a number of data tables or structures for textual and derived information. Some of the modules contain basic statistical data and others textual. Some modules may contain a mix of different data types. There are modules that define information derived or calculated from statistical data. Each module can be further expanded to specify detailed entities and attributes to be included. The sections below contain descriptions of the scope of the data contained in each of the identified modules.

While the descriptions of the modules (in this division of the system) are arranged to follow the flow of energy from resource to end-use, it should be noted that energy data and economic data are central to any energy information system. Being of a statistical nature, many analyses and definitions are applicable to both types of data, furthermore, both may be used in creating derived outputs in other modules. They must thus be classified by the same referential set to facilitate cross-referencing, not only across the energy module and the economic module, but for other modules as well. For example, the efficiency module (also crucial to energy information systems) uses data extracted from both energy and economic data modules. During query operations most numerical data will be also be derived or calculated from the energy and economic data in the system.

Data from individual organisations must be kept strictly confidential. This will require filters to limit unauthorised access and tools to ensure that data is aggregated in such a way as to prevent individual identification.

3.3.2.1 Resource data module

This module is designed to contain information on energy resources. Information on the size, quality and location of energy resources is important when investigating and analysing the energy industry, and in developing policy options. Matching supply with projected demand is important in the policy making process and a knowledge of resource size and availability is a requirement for the development of a realistic policy. Where resource data is available through third party information providers, links can be established to enable users to directly access the third party database through networks or Internet connectivity. In the White Paper, the DME noted that a "...national coal resource/reserve database will be developed, updated and monitored,..." (DME, 1998:68). This would be an ideal link for the system.

3.3.2.2 Energy data module

Energy data is defined as all numerical or statistical data concerning energy exploitation and utilisation. This module, where the physical volumes of fuel usage are maintained, is thus central to the data modules in the system. Energy data must be related to all four of the referential attributes from the point of exploitation to the burner-tip.

Energy data is of little use when simply available as a table containing all of the numerical data. This module may have other tables, and the system must have other modules that will permit the extraction and analysis of energy data in both fixed and user-definable formats.

Within the energy module, outputs will be essentially of two types - snapshot and time series outputs. The snapshot outputs will consist of a basic energy consumption table and an energy balance. These snapshot outputs may be of differing complexity. For example the restricted energy balance, as compiled by the IEA for some non-OECD countries where data is limited to a few broad sectors, can very easily be included as an output from the system. The comprehensive IEA balance is used as the standard balance output in this system and is given in Chapter 6 (6.3.1.2.ii), where system outputs are discussed.

The time series outputs are envisaged as being for individual fuels or fuel groups, rather than for all fuels in a single table. This is because the large number of data elements makes for very complex tables. Time series outputs are one area where the user will be given a range of options. Examples are included in Chapter 6, Section 6.3.2.

The energy data discussed above is all macro data (i.e. top-down or supply side). As noted in Chapter 2 (2.4.2.3.ii), there is a need to analyse energy consumption from the micro, i.e. bottom-up or demand side as well. Fuels are consumed to provide a service in specific end-uses. End-use, sometimes referred to as useful energy, was defined as "...heat, mechanical energy, chemical energy and light." (Kotzé, 1970:11). These four are the main end-uses for fuels although, given the rise in use of electronic equipment and computers, an electronic office equipment end-use could be added to the list. Another end-use that can be separately identified is transport. Transport use is mainly a mechanical end-use, as in motor vehicles and electric motors, although the use of jet fuel in aviation could be defined as thermal. There is merit in collecting and analysing data on transport use separately from mechanical use of energy. End-use knowledge is important, especially when analyses of inter-fuel substitution possibilities and opportunities are conducted.

3.3.2.3 Economic and demographic data module

For the purposes of this system the term economic data refers to more than financial data, and this module also includes all non-energy data to which energy data can be related. Thus population and measures of physical manufacturing output are two examples of parameters included in this module.

Some purely economic data (such as Gross Domestic Product (GDP) and Private Consumption Expenditure (PCE)), of a macro nature, must be available in this module. Detailed output data from individual economic sectors must also be incorporated to permit analysis at sub-sectoral level. Much of this is for the calculation of energy efficiency at end-use level. Some outputs will be simple replication of the economic data but most will be the result of further calculations.

3.3.2.4 Efficiency data module

Efficiency data is very broad in scope and can be divided and classified into many areas similar to those identified here for a broader information system. For this system, the narrow view of energy/economic ratios is the most important applicable to this module. Energy efficiency in this context is measured by determining the ratio of energy consumption and economic output for a specific process or industry. Changes in this ratio over time provide insight into improvements (or lack thereof) in the efficient utilisation of energy.

The most fundamental measure of efficiency is at process level, although this can generate exceptional volumes of data. At the highest aggregated level, efficiency is measured as total energy inputs related to total economic outputs (usually GDP). This latter ratio is not the best measure of energy efficiency as the structure of an economy determines the fundamental efficiency. It is, however, a measure used in many international comparisons. By this measure the South African economy is inefficient, because a very large component of energy is consumed by primary industries which contribute relatively little in terms of GDP. Downstream industries, which use outputs from primary industries as inputs to secondary processes, are generally far more energy efficient when measured in this way.

In the study published by the IEA on indicators of energy use and efficiency, a set of indispensable indicators was given (IEA, 1997c:11-43). These indicators provide a basic list of statistical data used to calculate energy efficiency that should be collected and included into an integrated information energy system. The indicators have been divided into aggregate and sectoral indicators. It must be possible to add additional indicators should a need be identified for further information. The list does not provide

a framework for indicators for individual users. These will be developed according to individual surveys where appropriate indicators can be identified.

Table 3.6: IEA indispensable indicators

1. Aggregate indicators

Primary energy vs. GDP
Stationary fuel vs. GDP (i.e. all non-transport use)
Electricity vs. GDP
Travel and freight energy use vs. GDP.

2. Sectoral indicators

Travel

Car ownership
Average new car weight
Distance travelled per car
Travel by mode pass-km/capita
On road fuel intensity
Average new car fuel intensity per unit weight
Energy use for travel GJ/capita per mode

Freight

Freight activity per mode t-km/GDP
Fuel intensity for trucks by size and fuel
Energy intensities of trucking MJ/t-km
Per capita freight energy use by mode.

Households

House area per capita
Domestic energy per capita
<other examples related to space heating/cooling>

Commerce

Floor area per capita
Energy use per floor area
<other examples related to space heating/cooling>

Manufacturing

Value added per capita per sector
Steel production per capita
Energy intensities by sector MJ/GDP (Sector)
Specific fuel consumption by sector (related to above).

All of these indicators are of a quantitative nature and show the importance placed on this type of data by the OECD countries. The energy efficiency data module should provide data tables and structures for calculating all these indicators.

3.3.2.5 Price data module

Price data, including taxation and subsidies, form an important element of any energy policy formulation exercise and are included in this system. The DME (1998:76) identified prices as an area for which information should be included. Price data must be available from resource to final end-use.

3.3.2.6 Environmental data module

There is an increasing international awareness of the risks associated with decreasing environmental quality as a result of energy consumption. The realisation that the exploitation and consumption of energy has an effect on the environment has made information on this link necessary. Some environmental data can be directly related to the consumption of energy and is essentially a calculation based on the volumes of specific fuels utilised. This information would be derived from the data contained in the energy data module. Other information is of a textual nature, where the objective is to provide information about the linkage between energy and the environment.

The effect of resource exploitation on the environment has become of serious concern, particularly in the developed countries. The energy industry is responsible for environmental degradation, some inherent in the processes used, some as a result of inadequate safeguards in the processes. Safety and adequate maintenance procedures can significantly reduce accidental

degradation. Planning and design can limit or eliminate degradation from certain processes, for example, opencast mining.

It is in the transformation and final consumption processes that emissions are difficult or impossible to control. Certain of the waste products can be contained and rendered harmless, others can not be controlled. One waste product that is of particular concern is CO_2. This is a natural product of combustion for all carbon based fossil fuels. Carbon dioxide is considered to be a greenhouse gas and there is a concern that global warming could result from increasing emissions. Methane is another greenhouse gas and unrestricted venting from the petroleum, natural gas and coal mining industries is an area of concern.

At the recent Conference of Parties to the UN Framework Convention on Climate Change conference held in Japan, the Kyoto Protocol was developed to provide guidelines for the reduction in greenhouse gas emissions (UN, 1997). The gases listed in Annex A to the Protocol are:

- Carbon dioxide.
- Methane.
- Nitrous oxide.
- Hydrofluorocarbons.
- Perfluorocarbons.
- Sulphur hexafluoride.

The Protocol specifies that all parties shall put in place national systems for estimating anthropogenic emissions by sources, and removals by sinks, of all the greenhouse gases not controlled by the Montreal Protocol. This implies that a national energy information system must be able to estimate emissions from the utilisation of energy sources. One solution is to incorporate the recommended methodologies into the official system, and calculate emissions

directly from the consumption data. Demand side data will facilitate the identification of major emitters. Focussed programmes can then be devised to reduce emissions from large identified sources.

Calculations of CO_2 emissions will come under scrutiny for compliance with the provisions of the Kyoto Protocol. The amount of CO_2 emitted when burning fossil fuels is calculated from the carbon content of the fuel burnt - 3,5kg of CO_2 are produced for every 1kg of carbon in the original fuel. The provision for the trading of carbon credits will require verifiable measurement of emissions (Hinchy, Hanslow, Fisher & Graham, 1998:45/46). The DME has noted that it will monitor international developments and will progressively balance environmental responsibilities and development interests (DME, 1998:85). This implies that a system for monitoring emissions will be required, as none currently exists.

3.3.2.7 Project data module

There are always opportunities for projects in the energy industry. Energy projects are often very large and costly undertakings. This module has been added as an area where information on current and potential projects can be maintained. Users of this area of the system are expected to include investors, energy companies, environmental organisations, international aid agencies and analysts.

3.3.2.8 Infrastructure data module

It is considered important to have information on existing infrastructure such as transmission lines, pipelines, railways and roads. Attributes (such as start and end points, distance, capacity and condition) for identified facilities would be maintained in this component of the system. Capacity constraints can place pressure on economic development and the policy maker needs to

be aware of potential bottlenecks. For both the energy industry and investors, a knowledge of the capacity and status of infrastructure is important for planning purposes. Information on investment in plant and infrastructure has been identified by government as important for planning purposes (DME, 1998:75). This module makes provision for maintaining this type of data. There is a link between information in this module and in the projects module. Once a project is completed, it forms part of the infrastructure of the country, and must be included in the infrastructure module. Having both modules in the system facilitates this link.

3.3.2.9 Contacts data module

This module answers the following kind of questions: 'Who owns the mineral rights? Who is the exploiter? The buyer? The user? The equipment provider? Who is the expert in this aspect of energy utilisation? Where can I get specialist advice and training?' It would be useful to have such contact details readily available. This module will provide this information.

Organisations from exploiters to users need to be contacted for information, or need to be advised of new technologies or legislation. This module is intended to function as a central repository of contact details.

It is also envisaged that links to other modules will be incorporated. For example, contact details of equipment manufacturers contained here, would be linked to data contained in the equipment module and also to the specifications module. For government, information on institutions linked to all areas for which data is collected is important (DME, 1998:76).

3.3.2.10 Specifications and standards data module

This module contains data on the specifications of both fuels and equipment. For fuels, information on physical and chemical specifications will be maintained. The White Paper notes that compliance to fuel standards and specifications will be compulsory in an environment of free trade in liquid fuels (DME, 1998:59). Calorific values and carbon contents will be other important attributes for which data will be included on a regular basis. This data, together with energy consumption data, is used to calculate energy balances and emissions.

Information on the performance specifications of all operational equipment will be included in this module. When appliance labelling is introduced, as noted in the White Paper (DME, 1998:78), then this data too will be included.

3.3.2.11 Bibliographic data module

Bibliographic data refers to the references for all articles, reports, books or papers that the system administrators believe will be useful to users. Some bibliographic databases already exist and could be incorporated. The domestic energy use database, for example, is largely based on bibliographic entries (Afrane-Okese, 1998). Abstracts or extracts may also be included. The information in this module would largely be extracted through keywords. Information here can link to that in other modules such as infrastructure, projects, case studies or policies.

3.3.2.12 Case studies module

Case studies are important to this type of information system, and their inclusion is considered essential. They can be used as a marketing mechanism and as a medium for disseminating information on the installation and

performance of new technologies. Case studies are particularly useful in demonstrating the economic benefit of installing new more efficient equipment. The British ETSU is a good example of an organisation providing case studies that can assist industry in implementing efficient energy utilisation practices (ETSU, 1999). Provision has been made in the White Paper for monitoring promising technologies (DME, 1998:69). Information in this module will be extracted from case studies, pilot studies or research reports provided by equipment manufacturers or operators.

3.3.2.13 International data links module

There are a number of databases maintained by national or international organisations that have data which could be useful. Some users will require access to these, and integration with these sources will simplify accessibility. The most useful access point would be through the Internet, where available. An example is the latest CD-ROM available from the EIA, which automatically directs the user to the EIA web site. The most recent version of selected documents or databases on the EIA server are automatically opened (EIA, 1998). The government considers international and regional energy information as important to include in a national information system (DME, 1998:76).

3.3.2.14 Products and equipment data module

A register of equipment, with specifications, technical details and supplier contacts is useful. Specification data is maintained in the specifications and standards module. This module should contain a listing of all available products and equipment. The Californian system as evaluated in chapter 2 (2.3.1.1.iii), could provide a working model.

In addition, this module should detail specific installed equipment, its location, fuel consumption and efficiency. This will make it possible to track CO_2 emissions at equipment level. Regional offices of the Department of Labour maintain a register of boilers, however fuel quality and consumption data would have to be obtained from operators. Details of other installed equipment would be more difficult to obtain.

3.3.2.15 Modelling modules

Because many planners will be using this system, modelling modules are added that utilise system data as inputs to mathematical models. The idea for this integrated information system was, in fact, conceived as a result of modelling work done by the author (Cooper, 1988). The government has recognised that integrated energy planning is an important issue and has set out a number of functions which include analyses requiring modelling of energy and economy linkages (DME, 1998:74/75).

3.3.2.16 Training and education module

This module will contain details of education and training institutions and programmes within the energy field. It is conceivable that on-line courses could be offered through the Internet using the Internet portion of the system as access point. The Internet offers exciting opportunities for distance learning courses (McCormack & Jones 1997:17-22). In particular the training of personnel in remote parts of the country, and in other countries, can be made easier through the Internet. Learners in remote areas can improve their skills at a much lower cost than conventional study methods without leaving their places of employment for lengthy periods. Training is a vital aspect of the energy industry, and this module provides a single access point to education institutions involved in energy training, and to other energy information and external links, as envisaged in this integrated information system.

3.3.2.17 Policies module

Information relating to national energy policy will be included in this module for potential investors and other interested stakeholders to access. All promulgated laws; proposed legislation; policy documents produced by the DME; reports and directives from industry regulators; and information on the regulatory environment must be included. Most data will be textual, accessed by keyword.

3.3.2.18 Rural energy module

A separate section containing information specific to rural energy analyses is considered essential as part of the ongoing efforts to provide viable energy sources to impoverished rural areas. It is expected that the data initially captured will be textual, but that as quantitative studies are completed, statistical data will be included. Geographic data on topics such as rural electrification and the location of rural communities could be included in a GIS compatible format.

3.3.2.19 Geopolitical data module

This module has been included as a possible area should the system be adapted for use on an international basis. A project to develop an energy information system for Africa (for the WEC) is currently in the conceptual stage (Cooper, 1999b). It includes a module for geopolitical data that could be used as the framework for this module. It is envisaged that potential investors will desire geopolitical information for strategic analyses.

3.4 ENERGY FLOW MODEL

Moving to a narrower view of the integrated energy information system, the focus moves to the flow of energy through the energy economy - energy utilisation or end-use. The four dimensions of the referential data set are intended to classify all data in the system in a uniform way. The flow of energy must be related to the interrelationships of these dimensions. As can be seen from Tables 3.4 and 3.5 the spatial and time dimensions are only referenced to a few criteria. The fuels dimension (Table 3.2) has many criteria, but is simply a list of fuel types to which data must be referred. The economic sector dimension, shown in Table 3.3, is far more complex. A model showing the relationship between energy flow through the economy and the four dimensions must depict this complexity.

One way of modelling the complex economic dimension is to show energy flow from resource to the point of final consumption. In the energy flow model (Figure 3.3) an aggregation of the economic sector dimension into six components is described. This aggregation of the criteria in Table 3.3 gives a different perspective on the energy economy showing energy exploitation, transformation and ultimate use as a flow process. The other three dimensions of the referential data set are placed athwart the economic sector, to show their affect on all levels of the energy flow in the economic dimension.

This brings the conceptual design of the system to the very narrowest level - final consumption. The final consumption model is discussed in section 3.5.

The first component in this energy flow model is the **resource**. This refers to the energy source or primary fuel. Attributes for which information is required include location, quality, quantity, economically recoverable volumes, owner and current status.

The second component is **exploitation.** This is the component where the amount and quality of the resource being exploited is tracked. Details of the exploiter can be included, as can any legislation governing exploitation. There are also other attributes for which incorporation is desirable. These include energy utilisation, exploitation technologies and equipment used, number of personnel, amount of wastes produced, and other environmental and economic factors associated with the exploitation process.

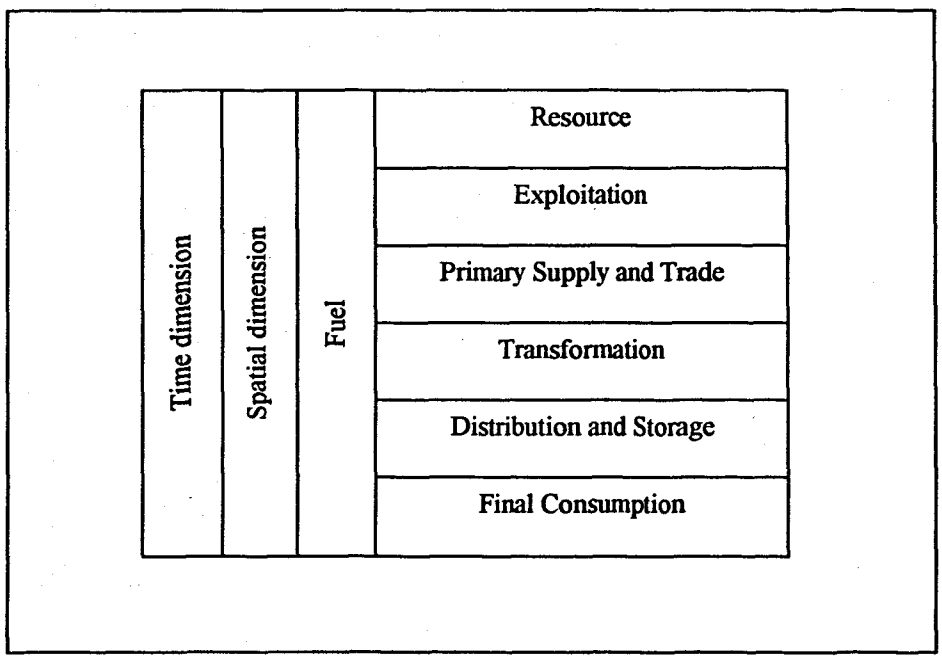


Figure 3.3: Energy flow model

The third component has been labelled as **primary supply and trade.** Attributes concerning production, imports, exports and stocks of primary energy sources, are included in this section.

The fourth component is **transformation** - most primary fuels need to be transformed to secondary carriers. This component maintains the volumes of primary fuels that are transformed, and the volumes of secondary fuel

outputs from the process. Energy consumed by energy transformers, e.g. electricity used by oil refineries, is also maintained here.

The fifth component is **distribution and storage.** Energy sources must be moved from the point of production or transformation to the end user. Some fuels can be stored. It is important to have information on these two aspects and to note losses in the distribution and storage process. Distribution and transmission losses for electricity; evaporation losses for liquid and gaseous fuels; and physical losses for solids, should be determined and included.

The sixth component is final **consumption.** Here information on the final consumption of energy is collated. There is a whole series of information that can be collected. End-use and equipment, efficiencies and economic outputs, are some of the more important parameters to be included. This final consumption component is so complex and important that a separate model has been developed for this level.

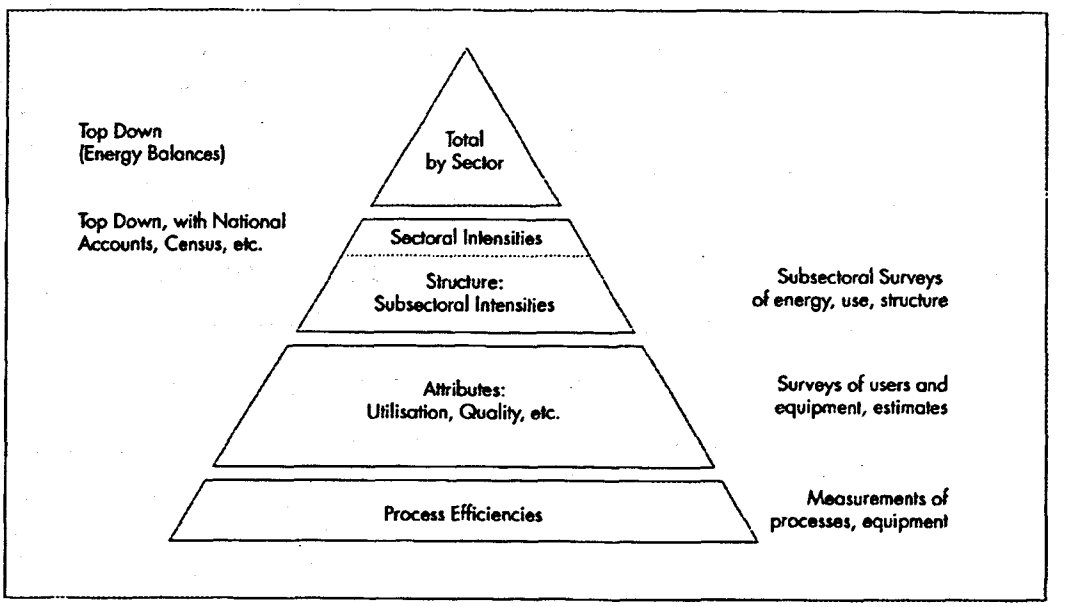
3.5 FINAL CONSUMPTION DATA MODEL

3.5.1 Rationale

The energy flow model unfortunately does not provide a complete model for energy utilisation. In particular the final consumption component is inadequately modelled, and a more detailed analysis is required at the most disaggregated - individual end-user - level of the information system. The development of a final consumption model is the last step in the process of designing an integrated energy information system.

Schipper developed a data pyramid to help explain energy utilisation indicators in a study completed for the IEA (1997c:50). The pyramid (Figure 3.4) provides an understanding of the structure of energy utilisation or flow

from individual processes to a total value per sector. The IEA pyramid also makes provision for economic and demographic information related to final consumer. It is thus a useful point of departure, although only the economic sectoral parameters of energy use are represented. The final consumption model developed in this thesis is a modified pyramid, designed to include the other three referential data set parameters.



Source: After K. Blok, University of Utrecht

Figure 3.4: IEA indicator pyramid (IEA, 1997:50)

3.5.2 Energy data pyramid

The modified pyramid was developed as the final consumption model in the conceptual design of the energy information system. In effect, this energy data pyramid corresponds to the last component of the energy flow model. In addition, economic and demographic information relating to the final consumer can be included at the appropriate level of the model. This data can then be related to the energy use at each level of the pyramid. The economic module (discussed in section 3.3.2.3) provides the point of capture and

classification for economic and demographic data. Similarly, modules on equipment, products, etc., will contain data on these topics. Unfortunately, while each level in the pyramid is theoretically the aggregation of all the elements in the level below, in practice the collection of demand side data in complete, accurate detail is impossible. It should, however, be possible to have accurate totals in the 'total' level and the 'sectoral totals' level, compiled from the supply side. For levels below, totals will become progressively less accurate, while individual details become more accurate.

The author identified four elements that are missing from the IEA depiction, but that are required for a more complete energy data model. These are: a total for the entire economy, a spatial dimension, a time dimension and a fuel dimension (Cooper, 1998a; Cooper, 1998b:6). Three of these elements have already been identified as essential referential data dimensions, and are shown in relation to final consumption in the energy flow model, Figure 3.3. The fourth element, total energy consumption, is an aggregation of the totals for all economic sectors. This aggregate is important to users who require energy utilisation totals.

The pyramid developed by the IEA has thus been modified to present a more realistic model of final consumption, for use in developing an integrated energy information system. The levels of the proposed structure are described, and then depicted in Figure 3.5.

The highest level, or total, reflects in a single number the total amount of energy used. This single aggregated number represents the sum of all energy consumption, and is referenced to the spatial, fuel, economic and time dimensions. This total can be for a single fuel (e.g. petrol), a grouping of some fuels (e.g. petroleum products) or for all fuels; consumed by a specified economic sector in a specified region and for specified time. For some analyses the total energy consumption for a country, or other specified

geographical area, is required. It could be required for a single fuel, for a selection of fuels or for all fuels. It is also required for a defined period of time (usually, but not necessarily, a calendar year). This single number could also be referenced to appropriate demographic or economic data contained in the system.

The second level has been labelled the sectoral level. The sectors referred to reflect a broad classification (as used in the energy balance developed by the IEA, and described in section 3.3.1.1.ii) of economic activity. For example: the Food, Beverages and Tobacco industry is one of the identified sectors and the data, for all those industries classified under this broad sectoral grouping, would be aggregated to obtain a sector total. This level is the equivalent of the top level of the IEA pyramid, in terms of economic data aggregation.

The third level has been labelled the sub-sectoral or industry level. This relates to the SIC classification of individual industries. The sugar industry or sub-sector would be included at this level as a component of the broad Food, Beverages and Tobacco sector.

The fourth, or lowest, level details the individual users within each industry. Thus each individual sugar mill within the sugar sub-sector would be identified at this level of the pyramid. Each user will have different processes and each process may have different equipment installed to drive the process. Using the example of the sugar mill, the process may be steam generation for syrup evaporation. The process is a thermal process but a single mill may have more than one production line with boilers from different manufacturers using different fuels. One may burn coal and the other bagasse. All these details give the full final individual consumption of energy. As previously mentioned, not all pertinent data can be obtained at this level.

Specific censuses or surveys would, however, collect this level of data for any subset, or combination of subsets, of the universe. For example, the Census of Manufacturing will provide data for the universe of manufacturing concerns. Totals for the first and second level of the energy data pyramid can be obtained from this universe. Data for the lower levels will need to be obtained from surveys, or sample surveys, from specific industries, or sections of industries, within the manufacturing universe. Results from sample surveys can be extrapolated to provide aggregated data for the appropriate level.

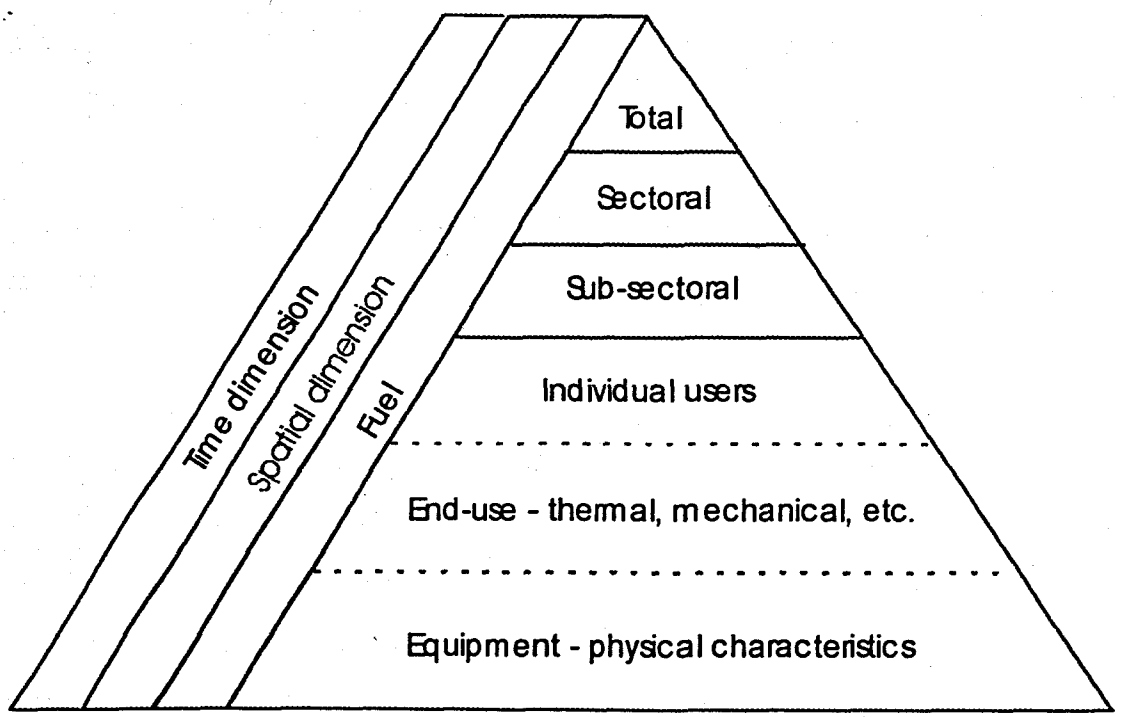


Figure 3.5 Energy data pyramid

Comparisons between energy and non-energy values provide the essential indicators required for measuring a region's energy economy and structure. These indicators provide an analytic framework to the formulation of energy policies, and a measurement of the efficacy of implemented policies.

Analysis of energy consumption alone does not provide much useable information for tracking the outcomes of energy policy decisions. It is only

when energy use is compared with other relevant economic, demographic and operational data that analysis becomes meaningful. Because the proposed system is an integrated system, data other than energy must be incorporated. The pyramid is as applicable to other data used in analysing the energy economy as it is for the basic energy data.

3.5.3 Implications of the energy pyramid model

A critical analysis, and full understanding, of the pyramidal structure for the data model indicates the magnitude of the challenge in designing an effective system. The implications of the pyramidal model are profound. This depiction is simple but it is not simplistic, and the effect on the development of an integrated system and on the creation of a data collection programme, are immense. The model provides a graphic representation of all the elements and their hierarchical relationships contained in the energy economy of any spatial entity or group of entities.

In particular, this model provides insight into the need for data collection exercises from both the top-down supply side (or macro) and from the bottom-up demand side (or micro) approaches. This dual approach was presented by Cooper (1994b) as a means of providing both the macro view (energy balances) and the micro view (end-use). Data collection and analyses done in the early 1990's focussed on the demand side (Cooper, 1993a:18-23) and provided very useful information on sectoral end-use of energy, but this was at the expense of macro analysis and the compilation of energy balances.

The solution is for the system model to make provision for data to be maintained at both levels. The supply side data will be stored in separate data tables and should be collected every year. The demand side data will be collected on an ad hoc basis, or at regular longer intervals, for identified sub-

sectors or industries. This data will be more detailed than the supply side data, and must be stored in separate data tables from the macro data.

At the present, the collection of data for every individual user at process and equipment level is a virtually impossible task for any country. There are, however, very good reasons for building the system so as to permit such data capture. It is only when analyses are done at process level that the true nature of, and forces driving, energy utilisation become obvious. Energy efficiency, as a topic for inclusion in policy formulation, relies on the identification and analysis of individual industries and processes as much as it does on the more aggregated analyses of major economic sectors. There is thus a need for detailed data just as much as there is a need for more aggregated data. Different analyses are done using data at different levels of aggregation, and the outputs must be able to meet as many of the different analysis needs as possible, preferably in an integrated information system using standardised definitions.

Data collection at different levels in the pyramid utilises different gathering techniques. For the top-down investigation, supply data from the energy industry is usually sufficient and is easily collected. There are some energy supply industries that use classification systems designed for their own particular circumstances and customer profiles. Such data will require careful analysis to reclassify volume data to match the referential data classification set. A different approach is required at the lower levels, one of specific, comprehensive and targeted surveys.

3.6 A PROTOTYPE SYSTEM AND IMPLICATIONS FOR IMPLEMENTATION

The philosophy behind the development of the conceptual model has been to define different data modules which can be stand alone entities but which all

refer back to a single set of referential data. This permits flexible implementation of the system. Provided the central control functions (as detailed in section 3.3.1) are developed, the system can be expanded as human and financial resources become available and information needs require the implementation of additional modules from the data component. This 'add on approach' was also recommended as the most prudent approach for the national energy efficiency database (Cooper, 1998b:48-52,55).

In this way implementation is not an 'all-or-nothing' action, rather modules can be added as and when required and resources permit. Expansion will however take place within a carefully reasoned master plan using a predefined set of protocols. Economic cost benefits should occur with such implementation because the parameters for the design of additional modules will be partially in situ and common components will have already been implemented. The system expansion costs would be less than designing and implementing each new module from scratch, and should definitely be less costly than setting up new independent systems for each module.

The final decision before conducting an economic assessment of the feasibility for implementation is the prioritisation of the data modules to be included, i.e. the order in which the areas for which information is required should be implemented. Once the modules are prioritised an economic feasibility study to determine the resource implications should be conducted, although such quantitative assessment is beyond the scope of this study. However, an estimate of the infrastructure and development costs for a system was obtained from a systems developer. This was based on experience gained in conducting initial development for a Southern African Development Community (SADC) system using the principles outlined in this study. Many of the cost benefits are a result of the rapid developments and improvements in both hardware and software technologies during the last decade. These have made such an integrated system financially beneficial.

directly from the consumption data. Demand side data will facilitate the identification of major emitters. Focussed programmes can then be devised to reduce emissions from large identified sources.

Calculations of CO_2 emissions will come under scrutiny for compliance with the provisions of the Kyoto Protocol. The amount of CO_2 emitted when burning fossil fuels is calculated from the carbon content of the fuel burnt – 3,5kg of CO_2 are produced for every 1kg of carbon in the original fuel. The provision for the trading of carbon credits will require verifiable measurement of emissions (Hinchy, Hanslow, Fisher & Graham, 1998:45/46). The DME has noted that it will monitor international developments and will progressively balance environmental responsibilities and development interests (DME, 1998:85). This implies that a system for monitoring emissions will be required, as none currently exists.

3.3.2.7 Project data module

There are always opportunities for projects in the energy industry. Energy projects are often very large and costly undertakings. This module has been added as an area where information on current and potential projects can be maintained. Users of this area of the system are expected to include investors, energy companies, environmental organisations, international aid agencies and analysts.

3.3.2.8 Infrastructure data module

It is considered important to have information on existing infrastructure such as transmission lines, pipelines, railways and roads. Attributes (such as start and end points, distance, capacity and condition) for identified facilities would be maintained in this component of the system. Capacity constraints can place pressure on economic development and the policy maker needs to

3.6.1 Cost estimates and options for implementation

Development of the SADC system design specification was estimated to cost between US$10000 and US$15000 while the actual system development should cost between US$30000 and US$40000, depending on user requirement definitions (Westerveldt, 1999). It was later estimated that writing the system over a period of 3-4 years would cost between 6 and 10% more, depending on the exact circumstances of implementation (Greeff, 2000). Between 50-60% would be required for the up-front system management and referential framework component development with the balance spread over the full implementation period. Despite this extra cost it would probably be the more prudent option, as problems can be more easily corrected and staff can become competent in installed components before the system is expanded. Another benefit is that the costs would be spread over a period of time rather than being a single investment.

In contrast, should a non-integrated system covering the same data areas be developed, it was estimated that development costs could be as much as 25-35% higher. Concerns about data flows, the compatibilities of imported and exported data and the management functions required for each individual system were the main reasons for this higher estimate.

All estimates exclude the costs of data collection, verification and capture. However if the same data were to be collected for either option the collection costs would be comparable, as would data verification and capture costs.

3.6.2 A prototype system and modular implementation

The initial focus in implementation should be on the development of the most important data modules. As noted, the structure of the referential data set and

general housekeeping modules must be completed before the system can be used. This will provide the basic structure onto which the statistical and textual data modules can be added.

The author determined that the energy data module, fuel specification sub-module, and economic and demographic data module, are the most important and should be the first priority. However a detailed prioritisation by the final system's users would need to be made before the system is officially implemented. A prototype software system was developed by DYSIS (1997) to provide a framework for maintaining SA energy data and calorific specifications for fuels. This prototype was developed from the principals and conceptual model as presented here and showed that the philosophy is sound. A detailed coding output is not included here, firstly because of the large number of programming lines, and secondly because it contains some proprietary programming techniques. Outputs from this prototype are included in Chapter 6 detailing the output framework to illustrate the concept.

The system was written in MS Access, Visual Basic and MS Excel running under Windows 3.11. Software limitations were an important concern and migration to a more robust set of development tools for a final system will be essential.

The prototype proved that a single system is feasible in practice and that the extraction of energy balances and time series tables took considerably less time than through other available means. There were definite benefits gained in terms of human resource efficiencies in conducting these basic extraction functions. The researcher estimates that the time saving could be as high as, or even higher, than a factor of ten but this cannot be empirically measured.

Similar, or even better, benefits should accrue if data modules with more detailed fuel specifications and economic data are added to permit the rapid calculation of, for example, energy efficiencies and carbon emissions. These analyses can only be done manually at this stage and no determination could be made of the time required for analyses. The proposed system should reduce time to minutes for each evaluation, provided that the required data has been captured, and depending on the physical infrastructure installed.

The DME has indicated in the White Paper that it intends to develop a database to support the Integrated Energy Planning (IEP) process. The system developed here will meet all the information requirements identified. The DME would have to ensure that any system implemented was sufficiently funded, and will show its intent in pursuing the IEP process by making long-term funding available, and should understand that system development and maintenance costs are perhaps 10% of total costs for operating the system. The total costs will include data collection, analysis, verification and capture. The researcher estimates that two skilled staff could manage this function at an annual cost of between R400000 and R500000 in 1999 rands. Excluded from this cost would be specific sectoral surveys to collect detailed data at establishment and process level.

For a relatively small investment in the physical system and in energy data analysts, many policy analysts and other users could benefit in having access to a uniform set of data records. It is difficult to estimate all the benefits for systems of this nature but it is obvious that the more the system is utilised the greater the accrued benefits.

3.7 SUMMARY AND SYNTHESIS

In this chapter a model of data flow from collection, through processing and storage to dissemination was presented to provide a broad overview of the

process. Next the conceptual model for an integrated information system was developed and presented. This included the system management and referential modules and modules for which data should be maintained. This model was developed from an analysis of the Energy Policy White Paper and from research into the information requirements for policy formulation.

Two further more detailed data models, although still at conceptual level, were developed to explain the hierarchical nature of energy utilisation. The first was identified as the energy flow model and depicted the flow of energy from the resource through exploitation, transformation and distribution to final consumption. The second was a pyramidal model developed to explain the structure and hierarchy of final consuming sectors. Without an understanding of all the relationships developed in all the models it will be impossible to develop the necessary framework for the proposed system. The data analysis framework for this conceptual design is given in Chapter 4, and is based on these relationships.

An external software company, using the model developed by the author, produced a prototype system focussed on statistical energy data. This was described briefly to demonstrate the flexibility of the modular implementation of the system. The outputs from the prototype appear in Chapter 6.

It was noted that the system could be developed in a flexible manner with additional modules being implemented as resources and data requirements dictate. This flexibility does not extend to the development of the system control functions and the implementation of a referential data set without which an integrated system cannot function. Although this conceptual study does not contain a detailed assessment of the economic viability of the system some estimates were made of system implementation costs and benefits.

Without an understanding of all the relationships developed in all the models it will be impossible to develop the necessary framework for the proposed system. The data analysis framework for this conceptual design is given in Chapter 4, and is based on these relationships.

CHAPTER 4: DATA ANALYSIS

4.1 INTRODUCTION

The system model developed in the previous chapter provides the best conceptual overview of the proposed system. The referential data sets and data modules were identified, and now the next stage is to identify the required entity sets (or tables) and their contents. The development of this more detailed data analysis is done in this chapter. The relationships between the different entity sets are also developed to present a more complete data model. The intention is not to produce a complete design specification for the system, but only to indicate the structure of the different system components. This layout can be used by systems analysts in finalising the system design specifications. Their task is to produce a document from which programmers will write the system software.

The first section tabulates the entities and their components. The second presents a diagram showing the linkages between the different entities.

4.2 DATA ANALYSIS

A useful way of presenting the structure and detailed accounting of the entity sets is to use a data dictionary (Rob & Coronel, 1997:77/78). The data dictionary provides a tabular record of the design of the entity sets and their structure, including the type, format, range and key requirements for all attributes. The layout used for this data analysis is not exactly that set out by Rob and Coronel, as it is limited to identifying and describing the different entity sets and their contents.

The system model is divided into the two main divisions, identified in Chapter 3 as the central control division and the data modules division. The data analysis is limited to those dimensions and modules of the two divisions that contain data -

whether referential, statistical or textual. System management functions and output structures are not shown, neither are the calculation functions for derived data (although the linkages for the latter are indicated in the model diagram). While not always noted the location or spatial data elements will always be in a GIS-compatible format. The data analysis is presented in Table 4.1.

Table 4.1: Data analysis

Referential data			
1	**Spatial referential set**		
		Location	Coding of geographical entity
		Description	Description of geographical entity
		Co-ordinates	Used for exact location of individual user
2	**Economic sector reference set**		
		Sector description	Description of economic sector/SIC
3	**Fuel referential set**		
		Fuel description	Description of fuels included
		Fuel unit of measure	Defines units in which fuels are measured
4	**Time referential set**		
		Time period	Defines time periods used

Data modules			
1	**Resources**		
		Spatial	Identifies location of resource – may be GIS co-ordinates
		Fuel	Identifies resource
		Specification	Refers to resource specification
		Company	Identifies owner and exploiter
		Value	Physical measure of resource size
		Textual	Contains textual information on resource
		Link	Link to third party database

Continued

2a	**Energy data (macro data)**		
		Spatial	Identifies spatial dimension code
		Sector	Identifies economic sector code
		Time	Identifies time period code
		Fuel	Identifies fuel code
		Volume	Registers volume of fuel used
		Specification	Link to fuel specifications for calculations
2b	**Energy data (micro data)**		
		Spatial	Identifies spatial dimension code
		Sector	Identifies economic sector code
		Time	Identifies time period code
		Fuel	Identifies fuel code
		Volume	Registers volume of fuel used
		Company	Identifies end user
		Fuel specification	Identifies specification of fuel used
		End-use	Identifies end-use of fuel (heat, mechanical, etc.)
		Equipment	Identifies equipment consuming the fuel
3a	**Economic data (macro data)**		
		Spatial	Identifies spatial dimension code
		Sector	Identifies economic sector code
		Time	Identifies time period code
		Economic parameter definition	Defines economic or demographic parameter
		Economic parameter value	Measure of the value of the economic or demographic parameter

Continued

3b	**Economic data (micro data)**		
		Spatial	Identifies spatial dimension code
		Sector	Identifies economic sector code
		Time	Identifies time period code
		Economic parameter definition	Defines and describes economic or demographic parameter
		Economic parameter value	Measure of the value of the economic or demographic parameter
		Company	Identifies end-user and exact location
		Equipment	Identifies equipment for which value is applicable
4a	**Specifications (fuels)**		
		Fuel	Identifies fuel code
		Company	Identifies supply company
		Time	Identifies time period code
		Specification description	Describes specification parameter
		Specification value	Provides specification parameter value
		Textual	Contains textual information on specification
4b	**Specifications (equipment)**		
		Manufacturer	Identifies equipment manufacturer
		Description	Describes and categorises equipment
		Model	Model number identification
		Specification description	Describes specification parameter
		Specification value	Provides specification parameter value

Continued

4c	**Standards**		
		Standard	Identifies standard
		Abstract	Provides an abstract of the standard
		Textual	Provides full text of standard
5	**Contacts**		
		Company	Details company information
		Company address	Both postal and physical address
		Company contact details	Gives telephone numbers, contact persons, etc.
		Company description	Describes industry and gives SIC coding
		Company location	Exact location for GIS compatibility
6a	**Price data - fuels**		
		Fuel	Identifies fuel code
		Time	Identifies time period code
		Spatial	Identifies location if required
		Price component description	Describes component of price
		Price component value	Provides price component value
		Price component unit	Identifies unit of measure of price component
6b	**Price data - exchange rate**		
		Time	Identifies time period code
		Currency	Identifies currency
		Exchange rate	Gives value of exchange rate

Continued

6c	**Price data - indices**		
		Time	Identifies time period code
		Index	Defines index
		Index value	Gives index value
		Base year	Tracks base year for index value
7	**Project data**		
		Project	Describes project
		Location	Provides location of project
		Fuel	Identifies fuel code
		Contact	Provides contact details regarding the project
		Project details	Details project parameters
		Status	Tracks status of project
		Abstract	Textual abstract of project
		Textual	Full textual reports linked to project
8	**Infrastructure**		
		Infrastructure	Describes infrastructure
		Location	Provides location of infrastructure - also start and end points of networks, GIS compatible where necessary
		Fuel	Identifies fuel code
		Contact	Provides contact details regarding the infrastructure
		Infrastructure details	Infrastructure operational and capacity details
		Status	Status and condition of infrastructure
		Abstract	Textual abstract of infrastructure
		Textual	Full textual reports linked to infrastructure

Continued

9	**Equipment**		
		Equipment type	Description of installed equipment
		Company	Identifies owner and operator
		Location	Exact location of equipment
		Time	Identifies time period code
		Fuel	Identifies fuel code
		Fuel specification	Identifies specification of fuel used
		Fuel volume	Registers volume of fuel used
		Textual	Full textual details on equipment
10	**Equipment characteristics**		
		Manufacturer	Manufacturer details
		Equipment type	Definition of equipment type
		Equipment specification	Refers to specifications
		Labelling	Contains details required for labelling
11	**Case studies**		
		Fuel	Identifies fuel code
		Spatial	Identifies location if required
		Sector	Identifies economic sector code
		Equipment	Identifies equipment installed
		Contact	Provides contact details for user and equipment provider
		Abstract	Abstract of study
		Textual	Full text copy of study

Continued

12	**Bibliographic data**		
		Fuel	Identifies fuel code
		Spatial	Identifies location if required
		Sector	Identifies economic sector code
		Contact	Provides contact details
		Abstract	Abstract of study or report
		Textual	Full text copy of study or report
13	**Environment**		
		Fuel	Identifies fuel code
		Spatial	Identifies location if required
		Sector	Identifies economic sector code
		Fuel specification	Identifies specification of fuel used
		Equipment	Identifies equipment
		Emissions	Calculation of emissions
		Textual	Full text copies of environmental reports
14	**International**		
		Link	Links to external international data sources
15	**Policies**		
		Abstract	Link to abstracts for policy documentation
		Textual	Full text copies of policy documentation
16	**Models**		
		Link	Links data in this system to operational models
17	**Training**		
		Link	Links to all institutions involved in energy related training
		Topic	Provides details of courses offered
		Contact	Provides contact details

Concluded

18	Rural energy		
		Fuel	Identifies fuel code
		Spatial	Identifies location if available
		Infrastructure	Identifies infrastructure (can be GIS related)
		Projects	Identifies rural energy projects
		Abstract	Abstract of rural energy reports
		Textual	Full text of rural energy documentation

4.3 DATA MODEL

The modules and their contents are all inter-linked and the main linkages or relationships must be fully identified. They will be exactly defined by a systems analyst during the development of the complete design specification. The intention is to present a view of the complexity of these relationships here and this has been done with a systems development tool. The resulting relationships diagram is presented in Figure 4.1.

4.4 SYNTHESIS

This chapter provides the initial data analysis that will be used by a systems analyst to initiate system design. It is the starting point for the development of detailed data table design and is the first level of systems specifications. An examination and tabulation of the different data areas for the proposed system, with a description of the content of each area, is given first. Secondly, an analysis of the relationships and major links between the data modules is given in graphic form. This model is not intended to show all possible links, as these will be exactly defined during the detailed design specification. Although the conceptual design developed here is the starting point of the detailed specification, the development of the design specification is beyond the scope of this study.

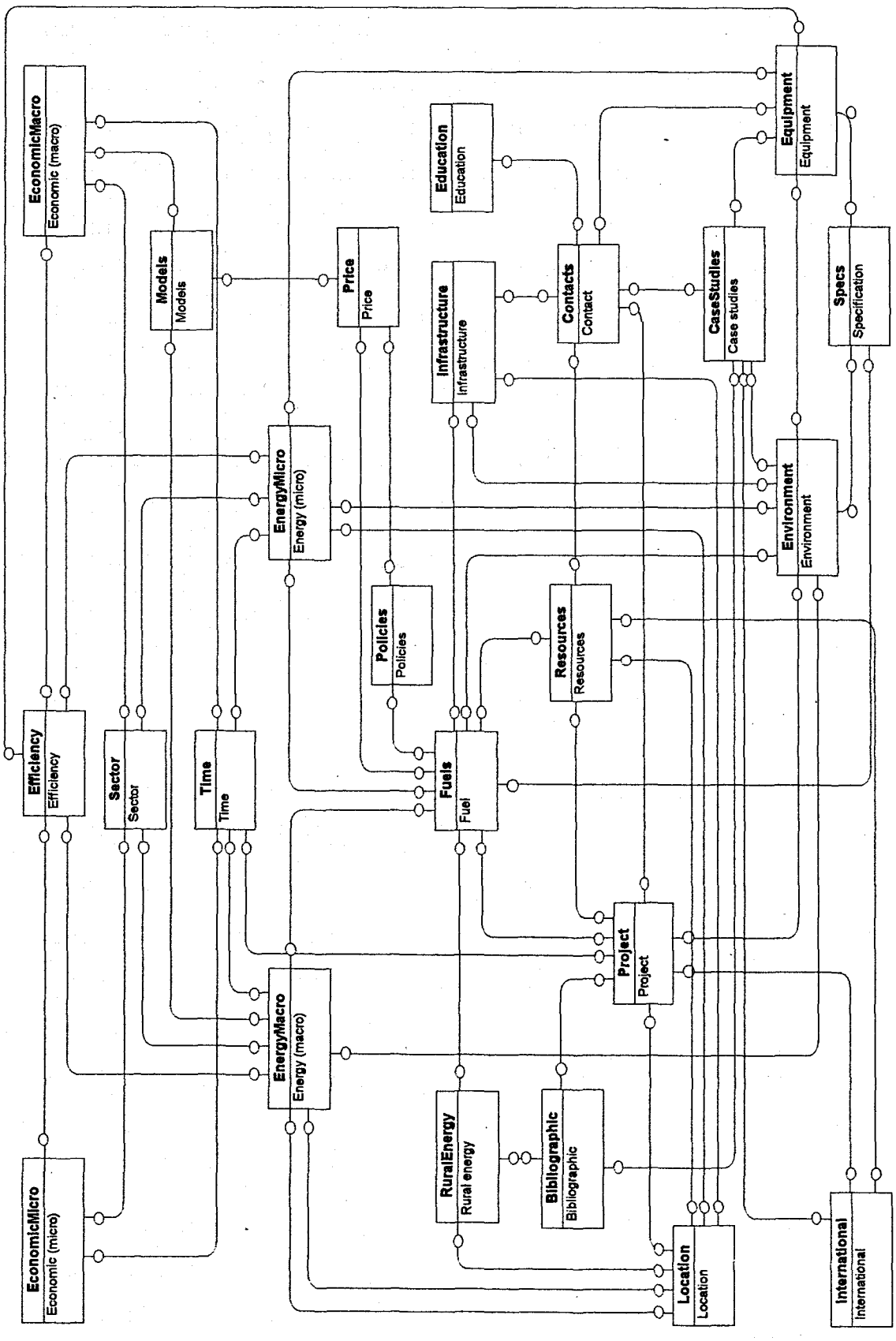


Figure 4.1: Data model

CHAPTER 5: INPUT DATA SOURCES FOR SOUTH AFRICA

5.1 INTRODUCTION

The South African energy economy is complex, with both First and Third World characteristics. Some sectors still rely entirely on non-conventional energy sources such as wood and dung, while others utilise electricity generated from nuclear energy. An understanding of the structure of the national energy economy is essential for both policy formulation and the task of designing and populating a national energy information system.

The energy economy includes all organisations and individuals involved in the supply, transformation, distribution and consumption of energy. When analysing energy inputs to the information system, the energy economy is divided into supply side and demand side components. This energy data is analysed in conjunction with non-energy data for the many derived outputs. Some sources of non-energy data input are briefly considered in this chapter.

The supply side data can be collected from the suppliers and distributors of energy, among who are some transformers of energy. These sources of data inputs are detailed in this chapter. Where possible, an indication of current (and historical) production, capacity, infrastructures, and links to other organisations is given. This information is intended to provide insight into the SA energy economy from the top down, and to give a starting point for supply side data collection and capture into the proposed system when it is formally implemented.

The demand side data can be collected from individual consumers, the transformation sector, and suppliers and distributors. The most detailed demand side data is collected from individual consumers, whether organisations, manufacturers, households, etc. Unfortunately, very little data

is currently available at this disaggregated level. More aggregated demand side data is often available from suppliers and distributors, in the form of detailed sales data, and an indication of these sources of input data is given.

An area that has not received the attention it deserves in current information systems and modelling efforts, is consumption of non-conventional energy sources. Information is virtually impossible to obtain and, other than this mention, no input details are given. Textual non-conventional energy data can be captured into the energy information system in the 'rural energy' module or, where statistical data is available, referenced to the relevant fuel in the energy data module.

For this analysis the economy is divided into supply, demand and non-energy sections. The object of this analysis is to give a brief overview of the supply side and its installed infrastructure; an indication of fuel consumption on the demand side; and a brief look at sources of non-energy data. Sufficient detail to populate the data structures is not provided, as this will only become necessary once the proposed system is fully implemented.

5.2 SUPPLY

Supply is defined as the production and import of primary energy sources and includes inputs to the transformation sector. The highest level of analysis is the aggregation of total primary fuels produced and imported, less exports, and taking account of stock changes. This is the primary energy supply for the country. An analysis of the primary energy supply provides insight into the structure of the energy economy, and this information can be used to calculate energy intensity at the highest level. Energy intensity at this level is usually expressed as the total primary energy supply per unit GDP or per capita.

From data collected during the intelligence phase of this study, an analysis of primary energy supply for 1997 was made. Provision was made for the export of both coal and finished liquid fuels (produced from imported crude oil and locally produced syncrude). The results are tabulated (Table 5.1) and shown graphically (Figure 5.1). From this analysis, the reliance of the country on coal as a primary energy source is obvious.

Table 5.1: Primary energy supply - 1997 (TJ)

	1997	%
Coal	3370 254	75.29
Crude Oil	450 863	10.07
Gas	71 814	1.60
Nuclear	137 967	3.08
Hydro	7 531	0.17
Renewables	438 104	9.79
TOTAL:	4476 534	100.00

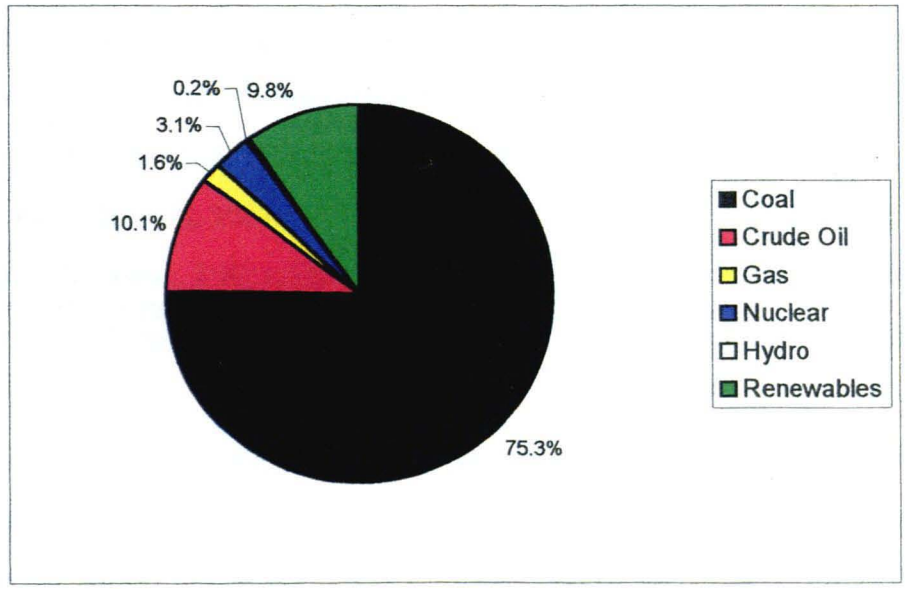


Figure 5.1: Primary energy supply - 1997

Primary energy supply in descending order on an energy supply basis is: coal, crude oil, renewables, nuclear, gas and hydro. Coal is used heavily in the transformation sector for electricity. Electricity is therefor a secondary fuel carrier and not included in the primary energy supply analysis.

A supply side analysis of the SA energy economy is provided in the sections that follow. This is a top down analysis, detailing the most important fuels (and their sources) supplied within the energy economy. Coal is followed by electricity, after which the oil industry is detailed. Nuclear and hydro energy are sub-sections of electricity supply and appear in that analysis. Gas is included in the oil industry analysis, as these sectors are closely linked in SA. Renewables, while large in volume in the primary energy supply analysis, are utilised by a few individual factories, and by many domestic users throughout the country, largely in the form of fuelwood, and therefor appear in the demand side analysis.

5.2.1 The coal industry

South Africa is endowed with large coal reserves and coal is the most important primary energy source. The most recent evaluation of the coal reserves of the Republic was published in 1987 (Bredell, 1987). The resources were reported as 121218 million tons and recoverable reserves as 55333 million tons (Bredell, 1987:14/15). In 1992 South Africa was fifth in the world (Minerals Bureau, 1993a:30) after China, the USA, Commonwealth of Independent States (CIS) and India as regards recoverable resources.

South Africa is a major coal producing and exporting country with production in 1997 being 220,07 million tons, of which 64,2 million tons were exported (Cooper, 1999a:17). Coal provided 75,3% of primary energy supply in 1997.

There are currently 78 collieries listed by the Minerals Bureau as operational, or which were being commissioned during 1998 (Minerals Bureau, 1999). There are 11 mining groups that control most of the production of coal in South Africa. Eight small independent producers were also listed in the Minerals Bureau directory.

The two major local uses for coal are the generation of electricity and liquid fuels production. Electricity generation consumed 61,2% of the local consumption of coal in 1997. Smaller amounts are used for the production of various gases and for the production of coke. Coal is also used in the various final demand sectors, principally for steam generation and heating purposes.

The supply of coal for electricity generation is mainly from dedicated collieries. These mines belong to the major mining houses. The mines belonging to Sasol at Sasolburg (Sigma Mine) and Secunda (Secunda Collieries: Brandspruit, Middelbult, Bosjesspruit, Twistdraai and Syferfontein) supply the coal used for liquefaction.

Prior to 1989 general marketing of coal was handled primarily by the TCOA and Natal Associated Collieries (NAC). The TCOA was started in 1923 to market coal for a number of the mining houses. A monopolistic situation resulted, with all coal sold on the general market having to pass through the TCOA's marketing network. NAC was closely affiliated to the TCOA and only broke away in the early 1980s. The lifting of price control over the wholesale and retail price of coal on 10 April 1986 altered the local market. The local marketing of coal by the TCOA was discontinued during 1988 and the individual mining houses now do their own marketing (Andrew, 1988). Small customers and retailers often purchase from wholesalers and merchants.

Historical coal data on coal production, exports and local utilisation is presented in Table 5.2 and Figure 5.2.

Table 5.2: Historical production, export and local use of coal (kt)

Year	Saleable Production	Exports	Local Use
1972	58440	1243	57197
1973	62352	1944	60408
1974	66056	2277	63779
1975	69440	2687	66753
1976	76543	5961	70582
1977	85411	12702	72709
1978	90358	15389	74969
1979	103768	23346	80422
1980	115120	29150	85970
1981	130420	29891	100529
1982	144176	28190	115986
1983	142845	30131	112714
1984	159549	38161	121388
1985	169825	44909	124916
1986	172446	45486	126960
1987	172785	42306	130479
1988	178215	42621	135594
1989	177678	46793	130885
1990	174990	49570	125420
1991	178460	49480	128980
1992	174420	49640	124780
1993	182270	52190	130080
1994	195750	54840	140910
1995	206210	59680	146530
1996	206360	60220	146140
1997	220070	64200	155870

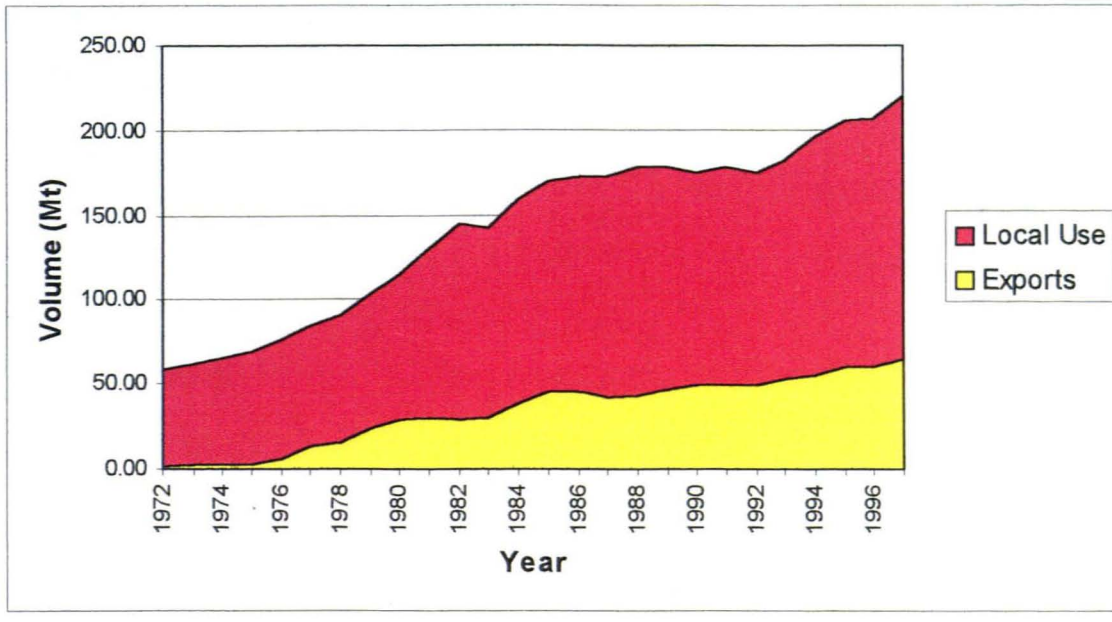


Figure 5.2: Coal exports and local use

As noted, South Africa is an important exporter of coal. More than 25% of production is exported. A sophisticated infrastructure network has been created to facilitate this export drive. In particular, Spoornet (the national railways organisation) has built a railway line from the Witbank area to the dedicated coal terminal at Richards Bay on the Northern KwaZulu coast. The Richards Bay coal terminal has a capacity of approximately 65 Mt per year. There have been recent announcements concerning expansion at Richards Bay through the South Dunes project (Creamer, 1999:1). During 1998, South Africa exported coal to a total of 35 countries (Prevost, 1999). These countries are primarily in Europe and Asia, as indicated in Table 5.3 below.

5.2.2 The electricity industry

Electricity is a very important and useful form of energy, because it is a very high quality and versatile energy carrier. There are many applications in the modern economy where electricity is the only energy carrier that can be used. Electricity is often taken for granted, yet it is a secondary fuel dependent on the transformation of other sources of energy and requires a high-tech environment. The infrastructure involved in the generation and distribution of electricity is enormous and costly.

Table 5.3: Coal exports by country and region - 1998 (t) (Prevost, 1999)

Country	Exports	Regional sub-totals
Belgium	3499961	
Bulgaria	194203	
Denmark	1542572	
Finland	99306	
France	3468848	
Germany	5984945	
Great Britain	1661085	
Greece	430713	
Ireland	234238	
Italy	4178037	
Netherlands	6544524	
Portugal	1409709	
Spain	3882297	
Switzerland	2934647	
Europe sub-total		36065085
Dubai	84507	
Israel	3873453	
Lebanon	16609	
Saudi Arabia	5643	
Turkey	1121539	
Middle East sub-total		5101751
Argentina	136153	
Brazil	2537148	
South America sub-total		2673301
Canada	41939	
USA	1591	
North America sub-total		43530
China	1053784	
Hong Kong	378764	
India	2150224	
Japan	3894722	
Malaysia	33000	
Singapore	36208	
South Korea	3116355	
Taiwan	1691076	
Asia sub-total		12354133
Mauritius	181884	
Morocco	1911262	
Namibia	68100	
Zimbabwe	48852	
Africa sub-total		2210098
	58447898	

Eskom is the largest producer of electricity in South Africa, producing an estimated 94,5% of South African production in 1997 (CSS, 1998:4). Sasol is the next largest producer, but all electricity generated is consumed in the company's own plants. Until recently, six municipalities (Bloemfontein, Cape Town, Port Elizabeth, Johannesburg, Pretoria and Kroonstad) generated electricity on a large scale with their own coal fired power stations. In 1987 Eskom (1987:12) noted that Bloemfontein was no longer generating and had decided to purchase all its electricity requirements from Eskom. The stations at Cape Town and Port Elizabeth have effectively been mothballed since the late 1980's and it is understood that Port Elizabeth has decided to decommission the Swartkops power station (Greyling, 1998). Johannesburg, Pretoria and Kroonstad still generate electricity, although they also buy from Eskom. There are a number of emergency units, mostly diesel powered, at some of the smaller municipalities (South African Municipal Yearbook, 1986:386/387; NER, 1996:6). In addition the towns of Lydenburg, Piet Retief and Ceres operate small hydro stations (NER, 1996:6). A number of large industries generate some of their own electricity. In particular the sugar industry uses bagasse, while the pulp industry uses black liquor, for electricity generation. The largest autoproducers are Sasol and Mossgas.

Coal is Eskom's main fuel for generating electricity (a total of 13 stations) although it also operates a nuclear power station with two reactors; six hydro-electric stations; two pumped-storage stations; and two gas turbines (Eskom, 1998:82). The production of electricity by fuel for all producers is given in Table 5.4.

Table 5.4: Production of electricity by fuel (GWh)

Year	Coal	Nuclear	Hydro	Pumped storage	Biomass	Imports	Exports
1990	153916	8449	1010	1841		229	5064
1991	154908	9144	1980	1804		254	5936
1992	156443	9288	752	1333	-	334	1814
1993	165835	7255	146	1345		100	2589
1994	170164	9697	1074	1517		54	2679
1995	174721	11301	529	1274	266	149	3000
1996	184952	11775	1319	2220	300	29	5579
1997	192705	12647	2092	2608	300	5	6617

Electricity is imported by Eskom from NamPower (previously the South West African Water and Electricity Commission (SWAWEC)). In the past electricity from the Cahora Bassa hydro-electric scheme in Mozambique was imported. Members of the Renamo resistance movement repeatedly sabotaged the transmission line during the 1980's. Following a political settlement in Mozambique, negotiations took place between SA, Mozambique and Portugal to restore the Cahora Bassa line. The line was rehabilitated during the late 1990's and it is understood that power deliveries began in August 1998, although details are unavailable because of sensitivity surrounding the topic.

Although Eskom sells bulk electricity to local authorities (who distribute it further to the end user), a large percentage of Eskom's sales are direct to end-users. Electricity is also exported to Botswana, Lesotho, Swaziland, Mozambique and Zimbabwe.

Eskom operates the national grid which comprises both transmission and distribution equipment. It is reported (Eskom, 1998:83) that there were 281010km of distribution lines, 6462km of cables, and 244586 transformers operated by Eskom at 31 December 1998. Details of this equipment are given in Table 5.5. This list excludes equipment owned and maintained by local authorities with licences to generate, transmit and sell electricity.

Table 5.5: Eskom transmission and distribution equipment – 31 December 1998 (after Eskom, 1998:83)

Main transmission system, km	765 kV	870
	533 kV DC (monopolar)	1 035
	400 kV	15 187
	275 kV	7 409
	220 kV	1 239
	132 kV	703
Total transmission lines, km		26 443
Distribution lines, km	165 – 132 kV	19 583
	88 – 33 kV	20 816
Total distribution lines, km		40 399
Reticulation lines, km	22 kV and lower	214 168
Total all lines, km		281 010
Cables, km	165 – 132 kV	47
	88 – 33 kV	243
	22 kV and lower	6 172
Total all cables, km		6 462
Transformers, number	Transmission	424
	Distribution and reticulation	244 162
Total transformers, number		244 586

5.2.3 The oil industry

The publication of information pertaining to petroleum and petroleum products was regulated by the Petroleum Products Act of 1977 (Act 120 of 1977, as amended) after an international oil embargo was placed on SA (South Africa, 1977). This Act made the publication of any information regarding the procurement, movement, stockpiling and sales of any petroleum product a criminal offence. It was thus impossible to compile a complete energy balance for SA using official data during these years. The international oil embargo was lifted in 1993, following changes on the local political scene. It will, however, take a while before all the previously secret information becomes available. The reason is mainly administrative, but there is also a perceived

strategic importance in withholding information. It may be impossible to fully obtain the crude oil balance for the years during which the Act was in force. The oil industry's supply side structure is analysed with regard to this situation.

SA has only one small productive crude oil field. This is the Oribi field south of Mossel Bay that produces 25000 b/d, commissioned in May 1998. This is only about 5% of the crude (and syncrude) required to meet local demand for liquid fuels, and crude oil must be imported for refining. Some refined product is also imported. Imported crude oil supplied an estimated 10,1% of South Africa's primary energy requirements in 1997 (Cooper, 1999a:2).

Oil is produced from coal in three indirect liquefaction plants at Sasolburg and Secunda, although the Sasolburg plant now effectively produces only chemicals and pipeline gas. Refined petroleum products are used mainly in the transport sector, where it accounted for 97,0% of the net energy demand and 89,6% of the useful energy demand by the sector during 1991 (Cooper & Kotzé, 1992:150).

Natural gas has been discovered off the Southern coast near Mossel Bay, near the mouth of the Orange River on the West coast in Namibian territorial waters and onshore in Mozambique. The Mossel Bay gas field is being exploited and liquid fuels are produced using the Sasol Synthol process at the Mossgas facility. There are plans to exploit the Kudu gas field off the West coast of Namibia and to produce electricity in a gas fired station.

There are currently ten oil companies operating in South Africa and their details are analysed below. Five are large foreign-owned companies, namely BP, Caltex, Shell, Engen and Total. The other five are South African owned, three being new black empowerment companies. These are Sasol, Zenex,

Excel, Afric Oil and Tepco. Engen (previously Mobil) had two marketing subsidiaries, Trek and Sonap which have been phased out.

BP South Africa is a wholly-owned subsidiary of the British Petroleum Company p.l.c., a British oil company. The South African head office is in Cape Town. BP is co-owner with Shell of the Sapref refinery near Durban. This refinery was commissioned in 1964, had a capacity in 1992 of 120000 barrels per day (b/d) and with further extensions capacity was increased to 165000 b/d by 1997 (South African Petroleum Industry Association (SAPIA), 1998:39).

Shell South Africa is an affiliate of the Royal Dutch/Shell group. This group is 60% Dutch and 40% British. Shell South Africa's head office is in Cape Town. As mentioned previously Shell and BP work closely as regards the operation of the Sapref refinery.

Caltex is wholly-owned by Caltex Petroleum Corporation, a company jointly owned by Standard Oil of California (Socal) and Texaco. The local affiliate has its head office in Cape Town. The Calref refinery at Killarney near Cape Town, commissioned in 1966, had a capacity of 50000 b/d in 1992 which was increased to 100000 b/d in 1997 (SAPIA, 1998:39).

Total is controlled by the French oil company, Compagnie Française des Pétroles (CFP), although about 35% of the shares are held by local investors. The company has its head office in Johannesburg. Total has a share (with Sasol) in the Natref refinery at Sasolburg through its subsidiary Total Refining South Africa (Pty) Ltd (Torsa). Natref was commissioned in 1972, had a capacity of 78000 b/d in 1992 and 85000 b/d in 1997 (SAPIA, 1998:39).

Engen was established in 1989 when Gencor's energy division purchased Mobil and reverse-listed it on the Johannesburg Stock Exchange into Trek

Beleggings. The listed name was changed to Engen Limited in May 1990. The purchase of Mobil provided the company with all the Mobil retail outlets; Trek and Sonap outlets; and the Mobil refinery in Durban. This refinery is now known as Enref. The refinery, commissioned in 1954, recently underwent upgrading which increased capacity to 105000 b/d from a capacity of 70000 b/d in 1992 (SAPIA, 1998:39). The company has also commissioned a sophisticated lubricants blending plant at the Island View terminal at the Durban harbour. The Malaysian national oil company, Petronas, acquired shares in Engen and recently secured a 90% stake in the company (Sharpe, 1998). Petronas delisted Engen from the Johannesburg Stock Exchange at close of business on 15 December 1998 (Paulse, 1999).

Trek was formed in 1968 by Shell, BP, Gencor and Federale Volksbeleggings. It, like Zenex, was a marketing company and had no direct interest in refineries. The company is now part of the Engen group, and Trek Service Stations have been phased out and replaced by the Engen trade name.

Sonarep also started operations in South Africa in 1968. It was an affiliate of the Portuguese oil company, Sociedade Naçional de Petroleos. The SA company obtained its products from a refinery at Maputo in Mozambique. After this refinery was nationalised in 1977, the South African company secured product from local sources. The company was very small, operating mainly in the Transvaal. Engen was the controlling shareholder with an 85% share (Anon, 1992:56). As with Trek, all Sonap service stations have been renamed under the Engen trade name.

Of the remaining companies, Sasol is the largest and oldest. It is a wholly owned South African company created by the Government in 1950 to produce liquid fuels from coal at a plant erected at Sasolburg. The head office is in Johannesburg. Apart from the original Sasol plant, the company has shares in the Natref refinery and also operates the Sasol II and III plants at Secunda.

The holding company is Sasol Limited that is 90% publicly owned, with government holding less than 10% through Conoil, an investment vehicle owned by the Industrial Development Corporation (IDC) (Joubert, 1999). Sasol sells its products directly to the other oil companies and also directly to the public via the so-called 'blue pump' at virtually all of the retail outlets within the Sasol supply area (DMEA, 1993:7/8). This is the geographical area where Sasol legally has first option to supply product. Sasol also produces large quantities of chemicals and surpluses of alcohols have, in the past, and again from the end of July 1999 (Sasol Oil, 1999), been added at about 12% to the 93 octane (research octane number) petrol sold by all of the oil companies in the 'blue-pump' area. Sasol started an intensive overseas marketing program and alcohol was exported to Brazil in the early and mid-1990's rather than being blended into local petrol. The capacity of the Sasol plants was recently given as 150000 b/d (DMEA, 1993:4/5).

In addition to the liquid fuels and chemicals production, Sasol also produces pipeline gas from coal. This is piped to customers in Gauteng, around the Witbank area of Mpumalanga, and to Richards Bay and Durban in KwaZulu.

Zenex is a wholly owned South African company that, prior to April 1987, was Esso South Africa, an affiliate of the Exxon Corporation. Political pressure on the American company led to disinvestment, and the company was taken over by its South African management. The company is small and operates in Gauteng, North West Province, some parts of Kwa-Zulu/Natal and around Cape Town in the Western Cape. The head office for the company is in Sandton. Zenex holds no interest in any refinery, but has a processing agreement with Enref (DMEA, 1993:3). It does have a lubricants blending plant at Durban. The Black empowerment group Worldwide has procured a share in Zenex (Naidoo, 1998). There have been recent press reports that Worldwide is negotiating with Petronas to merge with Engen (Cohen, 1999)

Three other black owned oil companies have been formed recently. The first of these is Excel Oil which is owned by several trusts and with Sasol holding a 22% share. The second, Afric Oil was formed in partnership with Caltex, although it has been restructured under exclusive Worldwide ownership. The third company is Tepco, owned by Thebe Investments. Tepco has focussed on the supply of product to public authorities and does not currently have any retail outlets (Naidoo, 1998).

Mossgas produces synthetic fuels using natural gas as feedstock to the Synthol process. The Mossgas project was launched in 1987, with commissioning of the onshore plant west of Mossel Bay taking place at the end of 1992. Production of natural gas from the FA gas field in the Bredasdorp Basin, some 85 km south of Mossel Bay, commenced on 31 May 1992 (Mossgas, 1998a). Both gas (210000 ncmph) and condensate (9000 b/d) are sent to the onshore plant where the gas is processed through the Synthol plant to produce a synthetic crude oil (Mossgas, 1998b). This syncrude and the condensate are then treated in a light oil refinery to produce (primarily) motor fuels. Mixed alcohols are also a by-product of the Synthol process. Mossgas generates about 90MW of electricity (about half of operating requirements) from reject reaction heat. The design production capacity of Mossgas is 30200 b/d of refined product which equates to 45000 b/d of crude oil refined (Mossgas, 1998c).

Apart from refineries, the oil industry infrastructure includes pipelines that transport liquid fuels. There are three main pipelines from Durban to the Gauteng region. One is a dedicated crude oil line that transports crude oil to Natref at Sasolburg via Ladysmith and Newcastle. A branch line from Vrede links Secunda to storage facilities in the Ogies area. The second line is an oil products pipeline which passes through Bethlehem and Kroonstad before linking to Natref and a smaller pipeline network which goes to, amongst others, Klerksdorp, Rustenburg, Pretoria, Witbank and Secunda. The third

pipeline is a former crude line that was converted to gas in 1996. This pipeline is from the Sasol plants at Secunda and goes to Durban via Newcastle and Empangeni. There is a crude oil pipeline from Saldanha Bay to the Caltex refinery at Cape Town and a gas pipeline from the offshore FA gasfield to the Mossgas plant.

5.2.4 Natural gas

Apart from the use of natural gas as a feedstock for conversion to liquid fuels at Mossgas as noted in section 5.2.3 there is no use of natural gas in South Africa. There is the possibility of exploitation of gas from gas fields in Mozambique and Namibia. A number of studies have been conducted to determine the feasibility of projects to exploit these resources. No projects are likely to materialise before 2005 because of long lead times, and as the market is currently insufficient to warrant the large investment required.

5.3 DEMAND

The demand side analysis details the utilisation patterns for energy within the energy economy. Coal is the first fuel discussed, followed by electricity. Next, petroleum products, the fuels refined from crude oil and the syncrude process, which are numerous and are analysed in detail. Other non-renewable fuels are then considered, and lastly renewable energy sources.

5.3.1 Coal

For convenience local coal consumption can be divided into transformation sector use and final use. The use of coal by Eskom for electricity generation and Sasol for liquefaction, as well as the conversion of coal to coke and coal gas, is defined as transformation sector use of coal. The major transformation uses of coal are for electricity generation (61,2% of local consumption in 1997)

and liquefaction (17,8%) (Cooper, 1999a:24/25). Transformation use of coal for the period 1972 to 1997 is shown in Table 5.6 and Figure 5.3.

Table 5.6: Transformation use of coal (kt)

	Electricity						
Year	Eskom	Other	Total	Liquefaction	Gas	Coke	Total
1972	24953	5340	30293	1333	1390	5486	38502
1973	27908	5252	33160	1463	1553	5496	41672
1974	30891	4613	35504	1220	1960	5713	44397
1975	34232	5226	39458	858	2271	5957	48544
1976	37257	5250	42507	931	2276	6675	52389
1977	37506	5113	42619	1098	2198	7377	53292
1978	39590	3520	43110	1349	2417	7018	53894
1979	43265	5400	48665	1050	2992	7264	59971
1980	46755	5568	52323	4350	3187	7158	67018
1981	53904	5428	59332	7340	3023	7007	76702
1982	55198	7855	63053	14386	3449	6623	87511
1983	55010	8785	63795	22248	3307	5300	94650
1984	58704	7729	66433	23845	3493	5600	99371
1985	59489	7877	67336	25595	3873	6000	102804
1986	58916	8280	67196	27045	3608	6248	104097
1987	65787	7872	73659	27397	3528	6075	110659
1988	64490	7361	71851	28179	3724	6671	110425
1989	67529	6727	74256	26786	3775	5238	110055
1990	70861	5390	76251	28267	3902	3608	110163
1991	70523	5432	75955	27057	3687	3557	110572
1992	71038	5799	76837	24457	6112	4866	112272
1993	75926	4797	80723	25317	4433	4702	115175
1994	76883	5674	82557	25506	4483	4141	116687
1995	79377	7060	86437	28051	4868	4220	123576
1996	85401	5492	90893	28526	4982	3958	128359
1997	90169	5483	95652	27766	5363	4072	132853

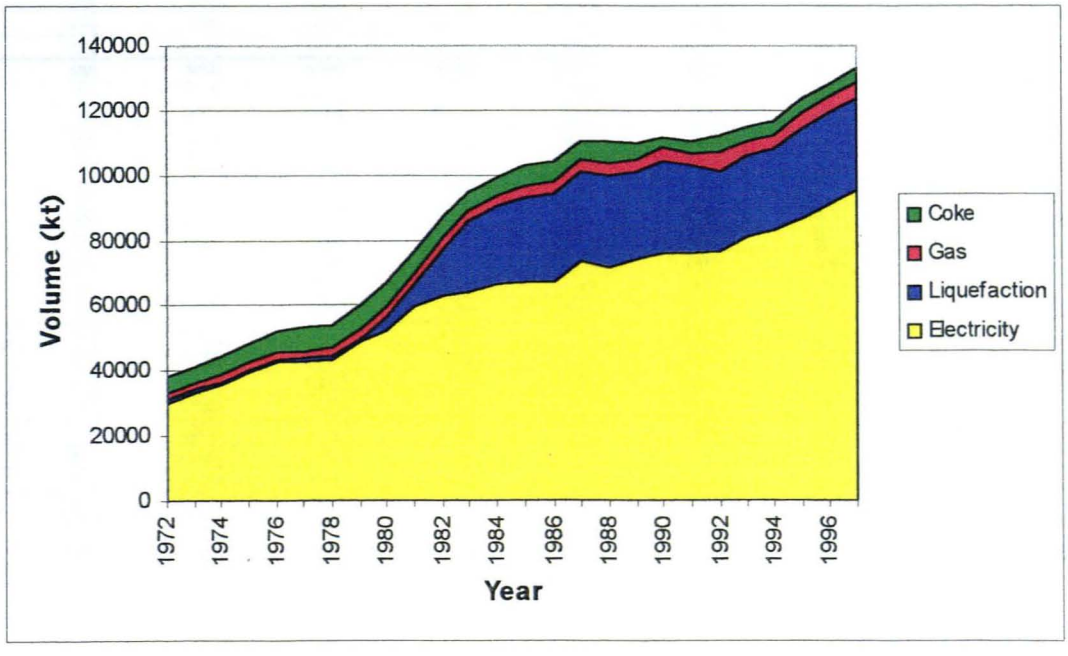


Figure 5.3: Transformation use of coal

The demand for coal for electricity generation increased rapidly after 1970 as new power stations were erected in Mpumalanga Province. Coal demand for liquefaction also increased dramatically after the completion of the Sasol II and III plants at Secunda. The amount of coal used to produce coal gas has increased because of increased sales of gas by Sasol Gas, a marketing subsidiary of Sasol. Some of the coal used by Sasol is a precursor for chemicals produced and sold both locally and internationally.

Apart from the transformation use of coal, there is also a final demand for coal. The largest users are the iron and steel industries and the non-metallic minerals industries. In particular, the cement, glass and brick industries are large users of coal. The local demand for coal by final consuming sectors has remained relatively constant since 1980 as can be seen from the information given in Table 5.7.

Table 5.7: The sectoral consumption of coal (kt)

Year	Agriculture	Domestic	Commerce	Transport	Mining	Basic metals	Chemicals	Manufacturing	Non-metallic minerals	Total
1972	119	920	1177	4337	1318	1161	991	4111	2302	16436
1973	119	915	1195	4025	1093	1512	973	4030	2552	16414
1974	123	933	1232	3403	1114	1556	1026	4227	2782	16396
1975	134	954	1312	3696	765	1680	1169	4366	2761	16837
1976	136	1010	1271	2780	816	2032	1591	4703	2545	16884
1977	99	968	1096	2553	1240	1989	1730	4102	2456	16233
1978	73	1033	1203	2241	1136	1970	2067	4164	2339	16226
1979	72	1013	1060	1977	840	1814	1868	3754	2089	14487
1980	88	1208	1119	1838	910	1915	1854	3915	2691	15538
1981	59	1332	1109	1725	1097	1900	1786	3360	2730	15098
1982	35	1357	1186	1466	881	2974	1857	4603	2638	16997
1983	29	1115	1121	1232	998	2037	1870	4174	2402	14978
1984	26	1452	1470	1126	855	2156	2042	5377	2569	17073
1985	49	1472	1329	938	697	2090	2080	5301	1953	15909
1986	48	1411	1081	861	710	2212	2168	4477	1931	14899
1987	31	1481	1028	720	641	2176	2153	4092	1982	14304
1988	30	1591	1178	413	613	2300	2207	5300	2075	15707
1989	29	1763	1320	158	505	2709	2065	5786	2095	16430
1990	47	1797	1338	69	465	2662	2202	5739	2211	16530
1991	64	1788	1455	36	438	2657	2057	5751	1977	16223
1992	213	2000	1755	9	506	2294	1661	5498	1597	15533
1993	183	2050	1182	94	470	2377	1375	4106	1470	13307
1994	299	2100	1040	42	388	3629	1177	3328	1723	13726
1995	296	2150	1758	54	603	3507	1580	4724	1607	16279
1996	242	2200	1302	23	555	2709	1665	4280	1206	14182
1997	241	2250	1356	2	1248	1758	1356	6428	1072	15711

5.3.2 Electricity

Eskom supplies electricity directly to local authorities (for redistribution); to most mines; to other (mainly large) industries; to rural customers; to Spoornet (railway) and to Petronet (pipelines).

Virtually all of the electricity used in the mining industry, the basic metals industry and, until 1986, the chemicals industry (with the exception of own generation by Sasol) is supplied directly by Eskom. In 1986 supply to AECI's Modderfontein factory was taken over by the Modderfontein municipality. Supply to a number of industrial and agricultural customers has been taken over by the relevant local authority. Until about 1990 Eskom had plans to sell further reticulation networks to local authorities. The situation has changed with the changing political situation, and the future structure of the electricity industry is not certain. The supply to some townships (such as Soweto) and the previous TBVC networks has been taken over by Eskom. The National Electricity Regulator, which was created in 1995, has proposed a restructuring which needs to be ratified by government.

5.3.3 Petroleum

The Petroleum Products Act of 1977 (see 5.2.3) means that estimates must be made for the years 1975 to 1994. Some aggregated data on local sales is available and was obtained from Caltex. This information was used to create Table 5.8.

Unlike electricity, which is a single product, there are a number of different petroleum products all used for different applications. Caltex acts as the secretary company for the oil industry and compiles sales data. This data is recorded on a magisterial district basis, using a market segmentation

classification specifically developed by the oil industry (Table 2.3). Data provided by Caltex has been used to analyse demand for individual products on a provincial basis, in the section that follows. Petroleum data is given here in great detail primarily to help fill in the gaps in the historical time series. This is the first time that data for the period 1985 to 1990 has been published. The abbreviations used for the provinces are as follows:

ECA	Eastern Cape
FS	Free State
GAU	Gauteng
MAP	Mpumalanga
NAT	KwaZulu/Natal
NCA	Northern Cape
NP	Northern Province
NW	North-West Province
WCA	Western Cape

Each of the main petroleum products will be discussed in the sections that follow.

Table 5.8: Local sales of petroleum products (Ml)

	LPG	Petrol	Illuminating paraffin	Power kerosene	Diesel	LFO	HFO
1985	243.50	6560.73	470.89	35.30	5061.77	41.27	661.45
1986	311.04	6772.26	498.42	32.05	4909.73	18.05	576.04
1987	340.48	7389.31	561.74	31.07	5050.95	17.29	544.17
1988	405.97	7994.69	640.85	30.20	5404.82	25.88	524.03
1989	432.30	8295.93	678.83	34.34	5354.20	14.76	545.03
1990	445.50	8633.32	723.69	31.64	5280.68	8.61	610.65
1991	473.67	8906.66	725.94	25.99	5124.47	7.10	526.18
1992	491.11	9170.44	742.86	22.02	4950.26	17.95	545.98
1993	468.48	9202.07	833.63	20.46	4939.77	37.03	591.84
1994	484.55	9629.57	874.80	20.05	5109.72	46.69	633.02
1995	492.39	10153.59	853.29	17.67	5441.22	159.64	657.58
1996	472.65	10566.75	916.99	15.02	5772.34	37.30	719.73
1997	527.37	10768.32	971.74	11.20	5870.40	42.26	634.30

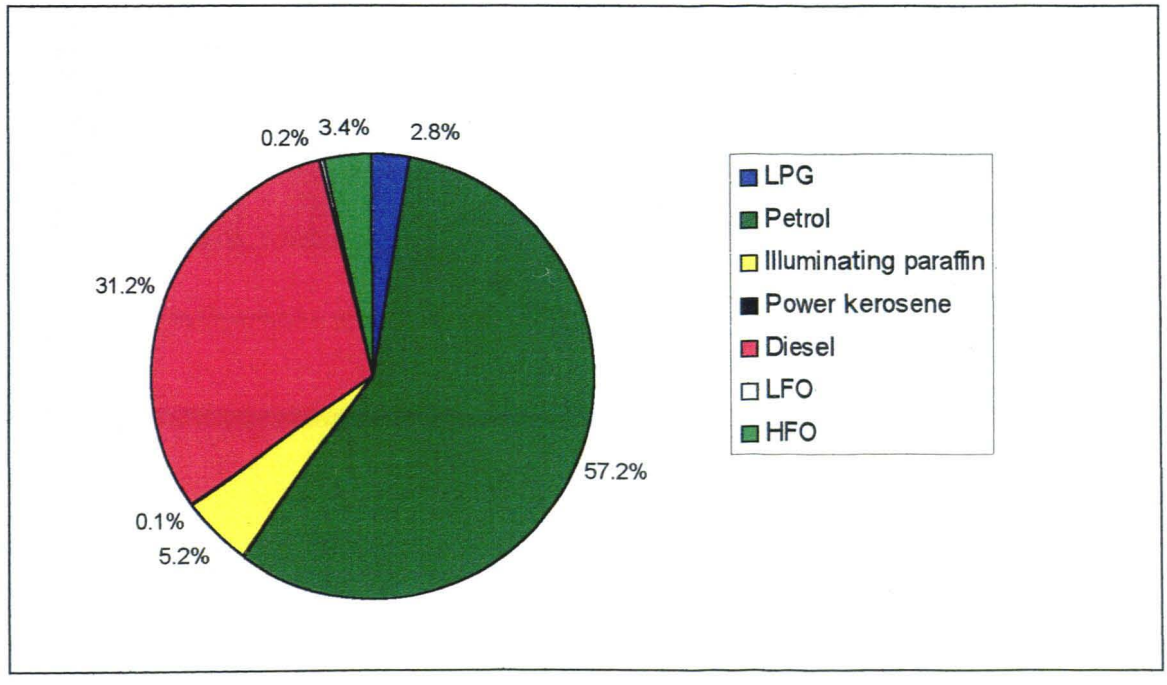


Figure 5.4: Use of petroleum products - 1997

5.3.3.1 LPG

Liquid petroleum gas (LPG) is used by the domestic sector for cooking and heating, and by the industrial sector for heating and for small fork-lift trucks. The demand has grown steadily every year. The domestic sector in particular

has shown large growth over the last decade. The main reason for this growth has undoubtedly been the lifting of influx controls in 1985, with the subsequent increase in the rate of urbanisation. Most of these migrants moved into undeveloped areas at the fringe of urban areas. Underdeveloped commercial energy reticulation networks and scarce firewood in these areas has resulted in a reliance on LPG and kerosene (Viljoen, 1989: as quoted by the National Energy Council, 1991:19). LPG sales and growth rates are tabulated and graphed in Table 5.9 and Figure 5.5 respectively.

Table 5.9: Provincial sales of LPG (kl)

	ECA	FS	GAU	MAP	NAT	NCA	NP	NW	WCA	Total
1985	23349	10412	67165	9725	62729	5408	6551	8001	50162	**243501**
1986	29612	14614	89606	11886	67890	7937	8395	13293	67805	**311037**
1987	31557	16027	94540	11106	75440	8542	9517	15146	78608	**340482**
1988	43482	18170	114944	14560	88390	8769	11710	22487	83460	**405972**
1989	49279	19091	117990	15994	93545	9007	14703	27975	84715	**432300**
1990	49262	21545	120998	17519	96768	9544	16149	30043	83675	**445502**
1991	47426	22574	120485	18696	113545	9241	17684	37016	87001	**473666**
1992	50614	23223	126352	19376	117311	9603	21497	33749	89381	**491106**
1993	50847	21317	122391	17584	113850	9164	20773	29516	83042	**468484**
1994	51100	25005	118379	20688	115322	8561	19700	41239	84553	**484547**
1995	49513	24484	127206	15139	117262	7363	21353	42278	87794	**492393**
1996	46126	22984	120652	12434	108522	6936	20743	48846	85402	**472645**
1997	48901	28205	125736	14870	122205	8215	21014	48890	109338	**527374**

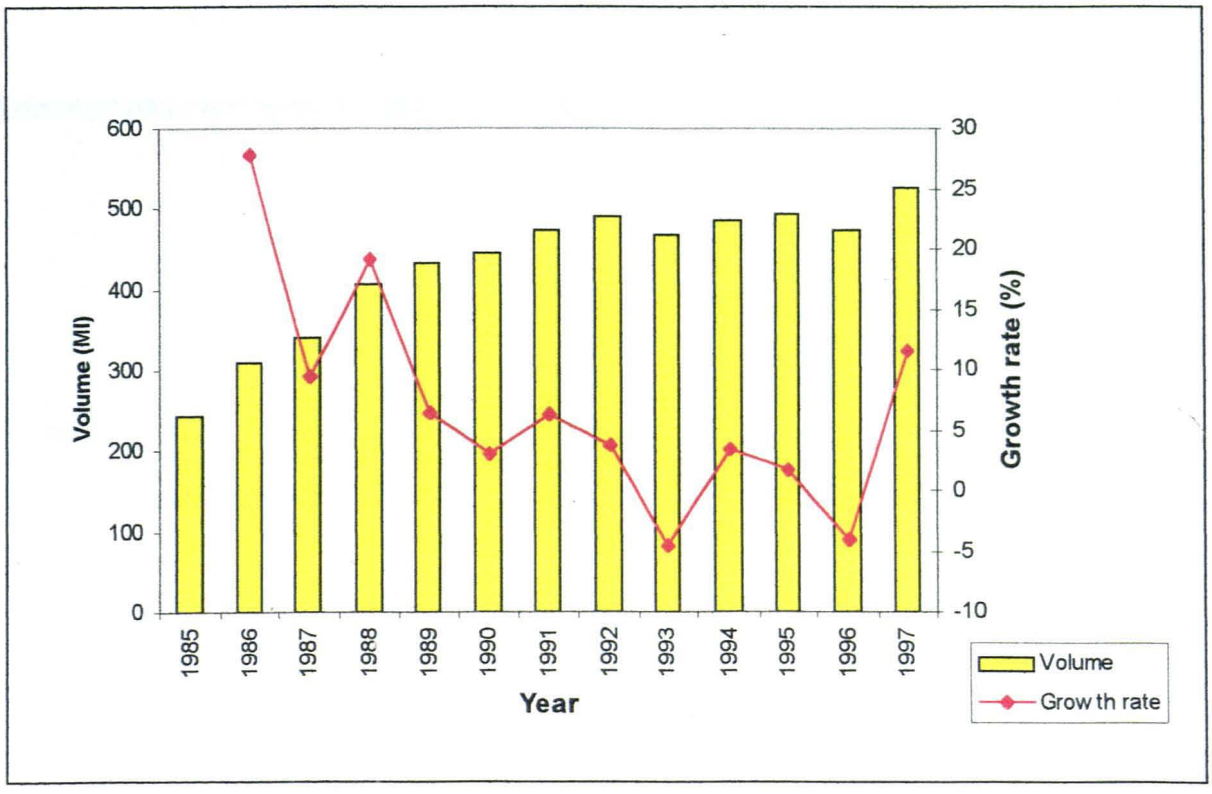


Figure 5.5: LPG sales and growth rates

5.3.3.2 Paraffin (or kerosene)

There are two grades of kerosene marketed in South Africa. Illuminating kerosene is used mainly by the domestic sector for cooking purposes. Power kerosene is used in old tractors in the agricultural sector, and for degreasing purposes in industry. The demand by the agricultural sector has been steadily decreasing as kerosene-burning tractors are scrapped. It is known that at one stage in the early 1980's the ongoing production of power kerosene was in the balance due to decreasing demand (Cooper, 1983).

As with LPG, the domestic demand for illuminating kerosene has shown a marked increase over the last decade. The reasons are similar to those for LPG. McGregor (1990) gives an additional reason: for a time traders in Natal (and presumably elsewhere) were purchasing low duty illuminating kerosene, adding it to diesel, and selling the blend at the higher diesel price.

Table 5.10: Provincial sales of illuminating kerosene (kl)

	ECA	FS	GAU	MAP	NAT	NCA	NP	NW	WCA	Total
1985	114644	46806	73858	27634	100963	11795	25447	34759	34987	470893
1986	119778	55352	75536	29801	105260	11694	26792	38561	35645	498418
1987	127536	65075	85604	33549	123963	12599	31413	45290	36711	561740
1988	144436	73964	97060	38557	141056	14323	37161	53140	41153	640849
1989	155246	68780	108743	42550	147857	14620	40260	58447	42329	678831
1990	159353	75693	113008	46701	153625	14626	51801	62940	45941	723688
1991	158602	78632	116452	53279	144050	14462	52925	61249	46295	725944
1992	165444	73940	121692	52052	142299	15801	54591	66064	50982	742865
1993	171320	76300	128616	90916	153816	21169	62631	77079	51786	833633
1994	186361	78462	136170	77359	176631	18484	62579	79301	59455	874803
1995	189672	70333	142661	52740	178510	16178	60765	77363	65069	853291
1996	190125	76525	158832	52056	204087	16717	66395	80280	71977	916994
1997	187883	80432	160266	57823	231206	16585	66687	92587	78266	971735

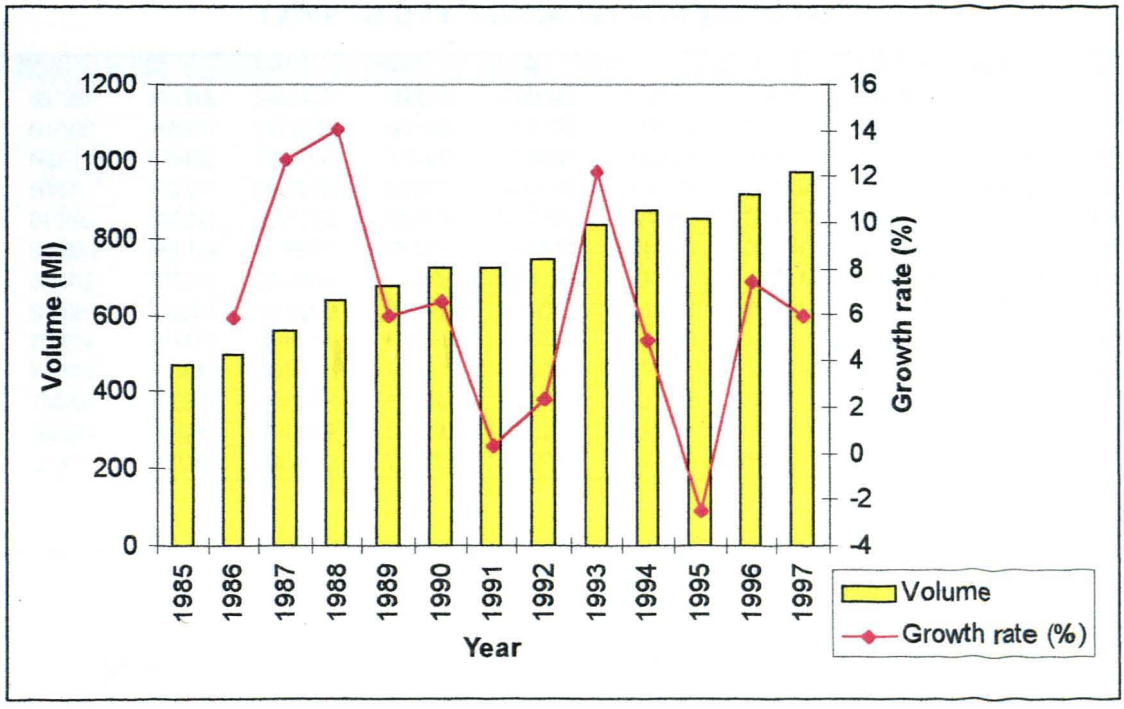


Figure 5.6 Illuminating kerosene sales and growth rate

5.2.6.3 Petrol

Petrol is used exclusively in internal combustion engines. The largest consuming sector is the transport sector, and more specifically private motorists and taxis. From studies done, it appears that the demand is marginally affected by price. One study indicated an elasticity of around -0.19 (Cooper & Kotzé 1989:148-155). Unleaded petrol was introduced during February 1996. Market share has remained low at around 10% of sales (Cooper, 1999a:34). Provincial sales of all petrol are given in Table 5.11. Figure 5.7 shows sales of leaded and unleaded petrol, and growth in total petrol sales.

Table 5.11: Provincial sales of petrol (kl)

	ECA	FS	GAU	MAP	KZN	NCA	NP	NW	WCA	Total
1985	497967	433318	2428126	450512	1040899	142311	249950	365934	951708	**6560727**
1986	507930	455576	2501229	467943	1067240	144856	271015	386093	970373	**6772255**
1987	542901	510152	2709324	515426	1158248	158797	319815	422683	1051964	**7389310**
1988	588251	551127	2908576	565601	1249142	172932	354157	460579	1144329	**7994695**
1989	615492	557066	3021098	578678	1297761	179462	378717	481721	1185938	**8295932**
1990	645633	562428	3132076	603219	1343147	184558	399840	502349	1260069	**8633321**
1991	675612	570315	3229414	620576	1384196	184666	427180	526118	1288585	**8906661**
1992	696584	579383	3326258	625163	1434027	188053	457184	533443	1330343	**9170436**
1993	705589	567470	3310061	623036	1460711	187040	468870	539601	1339689	**9202067**
1994	749956	591849	3441588	656911	1539757	193315	503232	559749	1393213	**9629568**
1995	790766	615359	3641276	692547	1631649	200703	522570	585433	1473284	**10153587**
1996	803372	626219	3812688	697190	1706275	210116	539515	598963	1567416	**10561754**
1997	823527	627266	3858510	736803	1718092	212106	556656	596410	1638953	**10768323**

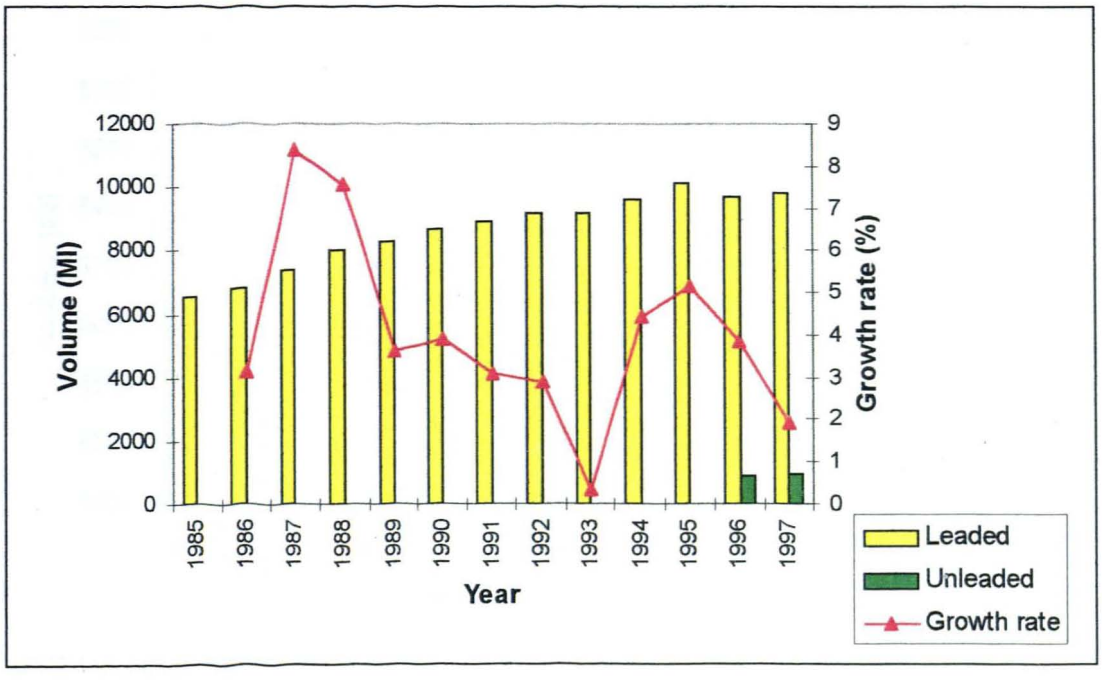


Figure 5.7: Petrol sales and growth rate

5.3.3.4 Diesel

Diesel (or automotive diesel oil (ADO)) is an important energy input to the freight transport industry, agricultural industry and the industrial and mining sectors. Apart from the obvious use in mobile diesel fuelled compression ignition engines, it also has applications in mobile off-road equipment, stationary engines and as a furnace fuel.

Table 5.12: Provincial sales of diesel (kl)

	ECA	FS	GAU	MAP	NAT	NCA	NP	NW	WCA	Total
1985	441295	553386	976023	640202	837963	234044	330659	408785	639413	**5061771**
1986	422969	539796	929894	632864	818958	219825	327195	405293	612932	**4909727**
1987	422597	556235	956648	636709	833268	220999	363117	408047	653331	**5050951**
1988	419666	591620	1041290	668347	917434	242056	363243	453306	707854	**5404817**
1989	379624	599481	1038036	662741	889780	269096	353635	465516	696289	**5354199**
1990	359748	543101	1010737	675886	875872	296716	346655	481573	690392	**5280678**
1991	335541	528074	986858	668497	838210	271446	337790	485191	672868	**5124474**
1992	334674	485169	965537	631034	824408	260298	336999	427886	684254	**4950259**
1993	328144	511739	961962	592253	857088	252880	336461	429728	669518	**4939774**
1994	332376	526369	1006720	644272	904755	255818	330604	420941	687865	**5109719**
1995	342960	548141	1057584	691108	960845	269623	367647	454470	748841	**5441220**
1996	363803	608322	1124786	723827	1026379	279066	390266	467425	788466	**5772340**
1997	365708	595959	1171115	735550	1044080	278200	401487	454449	823857	**5870405**

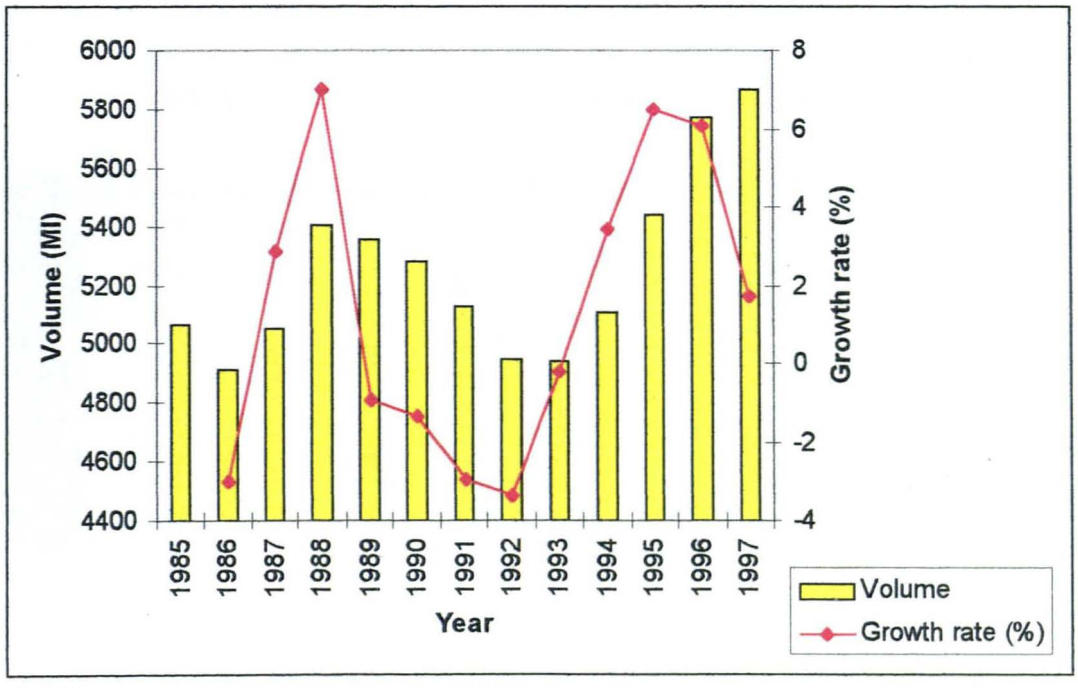


Figure 5.8: Diesel sales and growth

5.3.3.5 Furnace oils

There are two products classified as furnace oils - light furnace oil (LFO) and heavy furnace oil (HFO). A distillate fuel, LFO is also known as industrial diesel as it is essentially a diesel cut. It is not widely used, presumably because the price is comparable to ordinary diesel. HFO is a residual fuel and is mainly used as boiler fuel and in very large marine engines. Both these fuels are used by local industry and for international marine bunkers.

Heavy furnace oil (HFO) is used in large marine boilers and by the industrial sector. The demand after the 1973 oil crisis, particularly for on-shore applications, declined. Furnace oils are also used as a start-up fuel for electricity generation. The largest portion of local HFO sales are in KwaZulu Natal and in the Western Cape (Table 5.13). Included in HFO sales data are sales of what is in effect coal tar fuel produced by Sasol. HFO sales in the interior of South Africa are limited because of the low cost of coal. The decrease in sales in KwaZulu Natal in 1997 is believed to be largely a result of Sasol Gas being marketed in the area.

Table 5.13: Provincial sales of heavy furnace oil (HFO) (kl)

	ECA	FS	GAU	MAP	NAT	NCA	NP	NW	WCA	Total
1985	53648	10850	33077	80068	313447	1059	393	8957	159954	661454
1986	50981	11110	45842	89937	195956	768	2264	4503	174677	576038
1987	55172	18783	34259	84716	161418	1518	40844	279	147179	544167
1988	57048	9336	36906	80668	158873	1988	32458	1994	144762	524034
1989	51844	14112	46054	74503	181183	1588	25478	4425	145847	545034
1990	61537	14994	54858	108618	206380	2169	16840	3803	141446	610647
1991	61498	11726	39178	94452	156390	3100	22796	4441	132597	526178
1992	63128	11406	80471	62304	157586	2635	14335	5388	148727	545980
1993	61893	15088	105163	56101	179706	2981	19869	6459	144585	591845
1994	63763	14570	110460	47225	210827	3720	21149	7811	153491	633016
1995	71033	16764	100873	78915	195013	3287	21531	7315	162851	657582
1996	73549	18951	62054	70744	303753	1898	17010	7895	163871	719725
1997	64255	23323	51675	63214	239025	2104	17558	7412	165913	634479

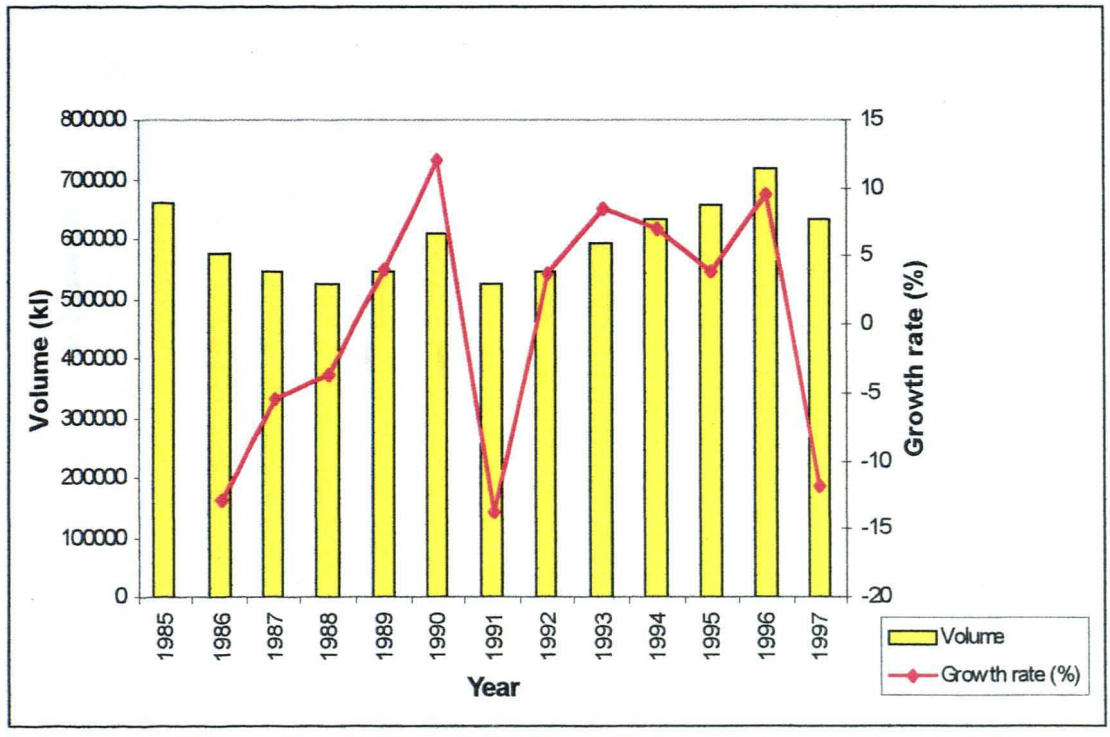


Figure 5.9: HFO sales and growth

Most of the sales of HFO are in the international marine bunker category. The relationship between local and international sales is shown in Table 5.14 and Figure 5.10.

Table 5.14: International and local sales of HFO (kl)

	Local sales	International marine bunkers
1985	661454	961280
1986	576038	815976
1987	544167	904986
1988	524033	1220122
1989	545034	1402543
1990	585802	1377169
1991	494873	1465022
1992	560109	1764607
1993	591845	2252000
1994	638478	2276785
1995	616107	2819961
1996	719725	2852076
1997	634300	3066353

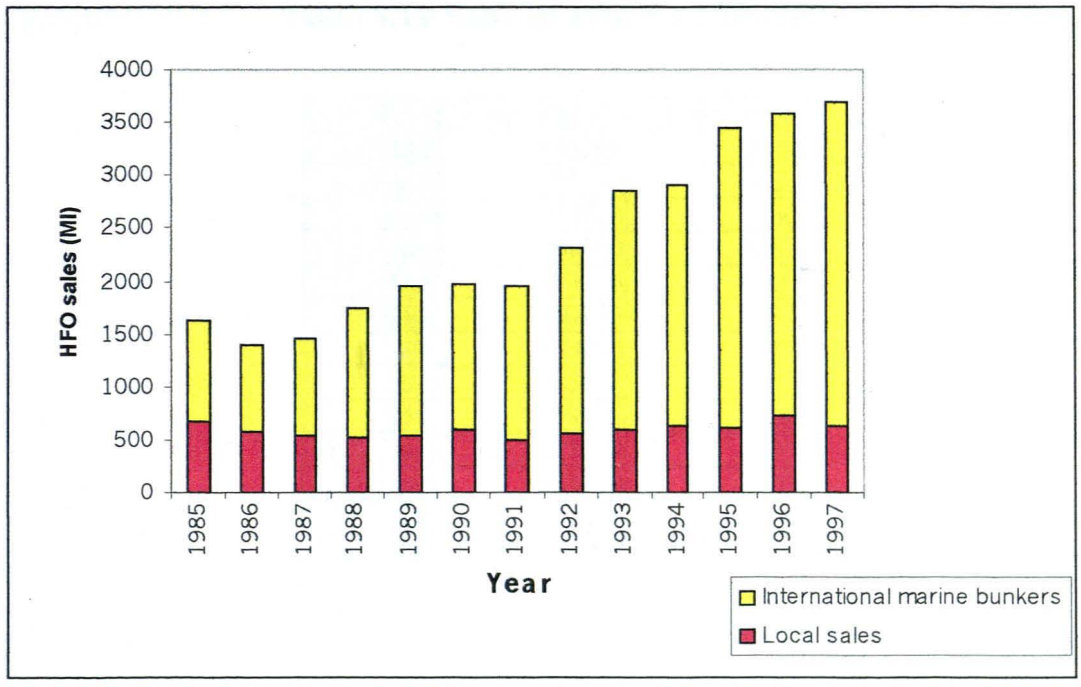


Figure 5.10: Local and International marine bunker sales of HFO

5.3.3.6 Aviation fuels

There are two aviation fuels - jet fuel and aviation gasoline (Avgas). The former is a kerosene-based product with rigid quality specifications. Prior to the introduction of intercontinental jet aircraft the demand was low but the use of jet engines in aviation ensured a very rapid increase in demand for jet fuel.

The demand for Avgas is linked to the small fleet of internal combustion powered aircraft. Prior to the introduction of the jet engine, this fuel was the only product used in aviation. Demand for international jet fuel has increased quite dramatically since the political changes after 1990, as more international visitors travel to the country. This is especially evident in the sales data included in Table 5.15 and Figure 5.11 below.

Table 5.15: Sales of aviation fuels (kl)

	Jet fuel	Avgas
1985	735265	28497
1986	687790	28308
1987	703928	29564
1988	784760	30612
1989	840075	31108
1990	860799	34416
1991	863993	31478
1992	1008817	29233
1993	1099626	24825
1994	1192533	26393
1995	1368410	26076
1996	1601006	25157
1997	1776386	28496

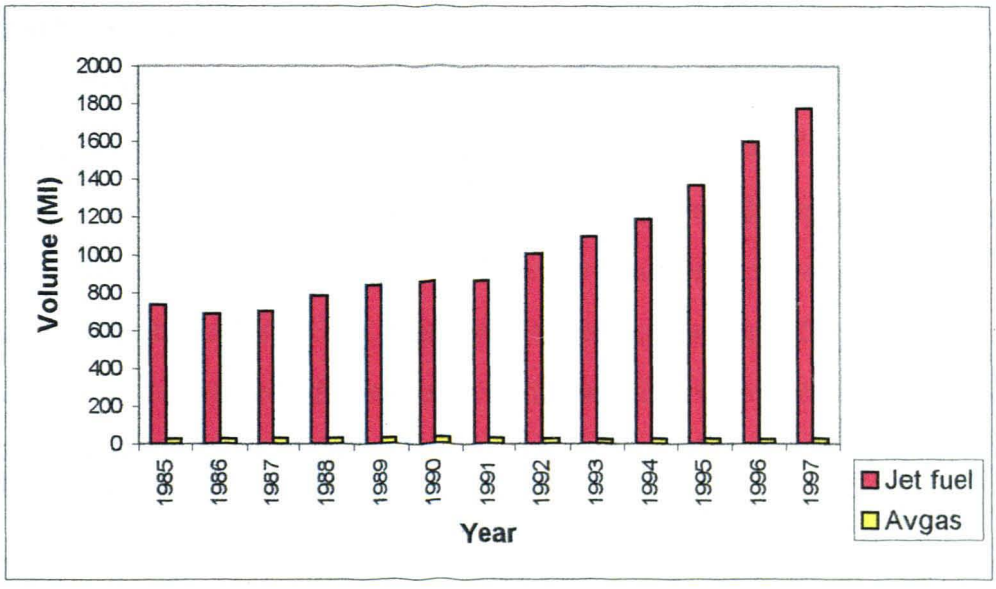


Figure 5.11: Sales of aviation fuels

5.3.4 Other non-renewable fuels

5.3.4.1. Coal gas

Coal gas (or town gas) is produced by Sasol and was in the past produced by the municipalities of Cape Town, Johannesburg and Port Elizabeth. The Port Elizabeth gas works was taken over by the Easigas subsidiary of Shell in 1988 and an LPG/air mixture is now supplied to customers. The Johannesburg

City gas works ceased production in June 1988, and all gas sold by the now renamed Metro Gas is purchased from Sasol Gas (the gas marketing arm of Sasol). This gas is a hydrogen-rich gas. The Cape Town gasworks ceased production at the end of February 1996 and pipeline gas is no longer marketed in the area. Sasol started marketing a methane-rich gas to the Middelburg/Witbank area in 1995, and to KwaZulu in 1996. The KwaZulu marketing area utilizes an existing liquid products pipeline operated by Petronet, the pipeline subsidiary of Transnet (Anon, 1996).

5.3.4.2. Other coal derived gases

Producer gas, blast furnace gas and coke oven gas are gases derived from coal. Producer gas is obtained by the partial combustion of coal in the presence of air. It is a low calorific gas (usually around 7 MJ/m^3) composed of mainly carbon monoxide and nitrogen, with small quantities of hydrogen, methane and carbon dioxide. There were a number of gas producers installed at various factories in the country. The current status of operational gasifiers is unknown, but with the expansion of the Sasol Gas network many are likely to have been decommissioned.

Blast furnace and coke oven gases are respectively byproducts of the production of steel in blast furnaces and coke in coke ovens. Coke oven gas is produced during the carbonisation of coal in a coke oven. The gas is of a relatively high calorific value (around 17 MJ/m^3) and is generally used within the plant. Iscor is the only producer and coke oven gas is used in the adjacent steel works at both Newcastle and Vanderbijl Park.

Blast furnace gas is a low grade gas, with calorific values around 4 MJ/m^3, produced by the partial combustion of coke in a blast furnace. The gas is high in carbon dioxide and has less hydrogen than normal producer gas. The gas

can be used although large quantities are flared in South Africa. This gas is limited to the iron and steel industry where blast furnaces are operational.

5.3.4.3. Coke

Coke is used primarily by the basic metals industry as a reductant and energy source in the steel making process. It is produced by the carbonisation of suitable coal, in the absence of air or oxygen, in an oven to drive off volatile chemicals leaving behind a solid carbon residue. The only producer of coke is Iscor. Iscor sells small volumes of coke to other industries, particularly the dairy industry.

5.3.5 Renewables

Demand for renewables can be divided into commercial and non-commercial use. Commercial use is, in general, limited to those companies utilising biomass as part of their processes. The timber, paper and pulp, and sugar industries all produce biowaste from industrial processes. For example, the sugar industry burns bagasse, or cane fibre, to produce steam for the evaporation of syrup. As there are a limited number of factories in these sectors, it is relatively easy to obtain consumption details.

Non-commercial biomass use is far more difficult to measure. There have been attempts but these have been isolated and the extrapolations are difficult to verify.

There is an increasing utilisation of solar energy for both passive thermal and photovoltaic use. Eskom has started a project in partnership with Shell to provide solar electricity to some communities. It will probably be impossible to measure the amount of energy provided by solar, although it should be possible to estimate numbers of installed units and their capacity.

Wind energy is another renewable that is gaining attention. Some wind powered installations have been erected in isolated areas. As with solar, it will be very difficult to accurately measure the amount of energy produced.

5.4 NON-ENERGY DATA

As noted in Chapter 3, non-energy data is needed to perform many of the analyses required for energy policy formulation. It forms an important part of the conceptualisation of this energy information system. Below, sources of national and sectoral data are discussed briefly.

5.4.1 National data

There are two official sources of macro economic data for the country. Stats SA and the South African Reserve Bank (SARB) produce comprehensive data series on various economic and demographic parameters. The Reserve Bank focuses on financial data and other macro economic data such as GDP, PCE, exchange rates and price indices (SARB, 1999). Stats SA produces a number of monthly, annual and other periodic publications covering a wide range of economic and demographic information. Many of these are available electronically through the Internet (Stats SA, 1999) or in hard copy from the Government Printer.

A few Stats SA series have been discontinued for budgetary reasons. As already noted the monthly series on petroleum product sales was discontinued in 1997. Another series discontinued was that of the number and type of motor vehicles registered in the country. This is of concern as liquid fuel use is linked to the motor vehicle population. The Department of Transport has assumed responsibility for vehicle registrations through the National Traffic Information System (NATIS) and data should be available for

the country. Licence renewal forms now require an odometer reading and this information will also hopefully be available for the analysis of transport patterns. The procedure for obtaining aggregated data for research purposes is not known.

Other organisations that compile national data include the Transnet subsidiaries of Spoornet for rail statistics; Portnet for marine statistics; SAA for air transport statistics. Customs and Excise can provide data for imports and exports and the Department of Labour for energy equipment, such as boilers, requiring registration. It should be possible to obtain these data for inclusion into a national information system. The Minerals Bureau (1993b) publishes details of operating mines and quarries with location and contact details.

5.4.2 Sectoral data

Many industrial associations exist and produce statistics for their particular industry. Examples include the South African Sugar Association (1997), the National Clothing Federation of South Africa (1992) and the Chamber of Mines (1995). Data on production volumes and values, location and contact details of members are often included in association publications. They are very useful sources of information, much of which can be included in the national information system.

Equipment manufacturers will be the sources for information on equipment specifications and operational data. They are often sources of case study data and can provide operational details of recently installed equipment.

Energy supply and distribution companies will be a source of data on installed infrastructure such as power stations, refineries, distribution and reticulation networks and depots.

5.5 SYNTHESIS

The focus of this chapter was on the energy economy of South Africa. Structures and sources of data were identified. The economy was divided into three components for this analysis. The first was the energy supply industry. Infrastructural details and data sources for different fuels were identified. The second was the demand side. For commercial fuels historical consumption was given. In particular sales data for the main liquid fuels for the period 1985 to 1997 were presented, this being the first formal publication of much of this data. Finally sources of both macro and micro non-energy data were identified.

CHAPTER 6: ANALYSIS AND DEFINITIONS OF DESIRED SYSTEM OUTPUTS

6.1 INTRODUCTION

The outputs from the system are described in this chapter, which concludes the conceptual framework of this thesis. While the outputs of a system are the end result of that system's processes, in reality the desired system outputs drive the entire development of the system. It is thus essential to know what information must be included in the outputs, in order to define what data needs to be collected and included in the proposed integrated system.

The user requires a system that will enable him to search for and extract information using specific search parameters. These search parameters determine the format in which the information can be extracted from an information system for further analysis. Experience gained by the author indicates that some output formats are rigid and standardised; some semi-flexible, and some totally flexible. It is proposed that the system be designed to take into account these different formats, which are discussed within each output area.

The major output areas developed and discussed in this chapter, are considered to be the most important for policy analysts. Because of the complexity of the module relationships and the specific output requirements of individual users, other analysts could develop additional outputs. It is important therefor to build a system that is sufficiently flexible to allow for later expansion.

The output framework presented here includes both those output areas that have already been included in the prototype system (for energy consumption statistics and prices) and outputs for areas excluded from the prototype. The layout of the outputs is in the same order as that for the data modules developed in the system model in Chapter 3.

One aspect which has not been covered in depth so far, is that of using a Geographical Information System (GIS) for maintaining data and presenting information. This is a vast topic, and a field of study in its own right. GIS is a very useful tool, especially where data has a spatial dimension as is proposed in this thesis. There are many outputs from this system that can be linked to a GIS. It is not the intention to create a GIS output system here, but, where applicable, mention will be made of the possible use of such software. The use of GIS as an energy policy tool was noted by the author (Cooper, 1995) but limited expertise and equipment prevented further development.

6.2 RESOURCES

Information on the resource base is important for the policy formulation process. Knowledge of the size and distribution of a particular resource, and alternative resources, can be used to develop a realistic policy regarding exploitation options.

Collection and analysis of resource data requires specialist knowledge that will probably be beyond the expertise of energy directorate personnel. The Council for Geosciences does however collect non-renewable resource data and maintains a database. Electronic access to this data will be the most cost-effective means of incorporating non-renewable resource data into the proposed system, although full integration would also be possible.

The output format will then be constrained by the resource system design and the referential data set used. Compliance with the standardised referential data set will be essential for seamless incorporation. A goal of the current national coal resource inventory project managed by the Council for Geosciences, is an output in electronic format. Access will most likely be via a GIS interface. By clicking on a coalfield or farm shown on screen in map form, details of the resource for the

specified spatial entity will be available (Wipplinger, 1999).

Non-conventional resources pose a greater challenge in the collection of data, but capture of available data in a GIS-friendly format will permit outputs using the GIS graphical or tabular structures. One resource which should readily be convertible to GIS is the wind atlas compiled by Diab (1995). Similar information for solar radiation (Eberhard, 1991) and biomass potential could be included, once evaluated.

As there are many unknowns in how the outputs should look, it is only possible to indicate the important information required. The minimum information must include:

- Fuel.
- Quality.
- Volume at specified location.
- Owner of resource.
- Exploitation status.

6.3 ENERGY OUTPUTS

6.3.1 'Snapshot' or specific period outputs

A snapshot is a view of energy consumption for a single, specified time period. The most common period used is that of the calendar year, but may be for months, quarters or other defined periods. New Zealand, for example, produces outputs for the year ending in March (Ministry of Commerce, 1994b:108).

There are essentially three snapshot outputs which are of interest to the policy maker or analyst:

- Basic consumption data in conventional units.
- Energy balances.
- Flow diagrams.

Each will be discussed and templates, where appropriate, will be developed and presented.

6.3.1.1 Basic consumption data

The starting point for data compilation must be the tabulation of the use of each fuel, disaggregated by economic sector and geographic dimension, for the specified time period. The data should be collected and maintained using the normal units of measurement. For example, solid fuels are measured by weight or tons (t), liquid fuels by volume (kl), electricity in kWh, gaseous fuels in cubic metres or GJ and heat in GJ. Suppliers usually sell fuels using these conventional units of measure, and virtually all supply and demand records are in these units. Logically the collected data should initially be captured into the system in these basic units of measurement for ease of integration and extraction. (It must be remembered however, that data conversion to a single unit of measure becomes necessary for other outputs.)

The first, and most basic, output must thus be a tabulation, on a spatial basis, using the basic units of measurement. It is also logical that the output should be structured in an easily understood manner. To reduce later data manipulation it is proposed that the outputs be in a form from which the energy balance (using a single unit of measurement) can be readily calculated. The structure of this output is based on the IEA matrix of fuels and sectors using normal units of measurement.

The basic consumption output table contains data on energy flows for individual fuels and divides this data into five distinct sections. The sections into which the

data is allocated are listed below, while the fuels covered were tabulated in Table 3.2.

- Primary supply.
- Transformation.
- Energy sector.
- Final consuming sectors.
- Non-energy use.

(i) Primary supply

The section on primary supply contains data on local production, imports, exports, international bunkers and stock changes of all the fuels utilised. The elements to be included are tabulated in Table 6.1 below.

Table 6.1: The primary supply sector elements

Indigenous production
From other sources
Imports
Exports
International marine bunkers
Stock changes

(ii) Transformation sector

This section is concerned with the conversion of primary fuels to other secondary fuels. As an example, coal is converted to electricity in coal fired power stations. The complete list of elements in this section, for the consumption table, is given in Table 6.2.

Table 6.2: Transformation sector elements

Public Electricity Plant
Autoproducer Electricity Plant
Public CHP Plant
Autoproducer CHP Plant
Public Heat Plant
Autoproducer Heat Plant
Heat pumps
Electric Boilers
Patent Fuel Plants
Coke Ovens
Gas Works
For Blast Furnace Gas
Petrochemical Industry
For BKB
Oil Refineries
Liquefaction
Non-specified (Transformation)

Two of these elements need further explanation. Patent fuel plants produce a composition briquette made from coal fines with the addition of pitch as a binding agent. BKB (Braunkohlenbriketts) plants produce fuel briquettes from brown coal fines without the addition of binders.

(iii) Energy sector

The energy transformation and production sectors use energy in the transformation or extraction process. This is not a final demand, as the amounts used depend on the amount of fuels transformed or produced. Thus, the use of electricity in oil refineries is not a final demand but more correctly use by the energy sector. Table 6.3 indicates the elements in this section of the consumption table.

Table 6.3: Energy sector elements

Coal Mines
Oil and Gas Extraction
Patent Fuel Plants
Coke Ovens
Gas Works
BKB Plants
Oil Refineries
Own use in Elec., CHP and Heat plant
Used for Pumped Storage
Nuclear Industry
Non-specified (Energy)

(vi) Final consuming sectors

These are the sectors that consume energy for activities other than for transforming or producing fuels. The consumption of energy by this sector is the driving force behind the production, import and transformation of energy sources. Final consuming sectors are subdivided into three groupings, these being industry, transport and other sectors. The sectors analysed for this section of the final consumption table are tabulated in Table 6.4.

Table 6.4: Final consuming sector elements

Industry Sector
Iron and Steel
Chemical and Petrochemical
Non-Ferrous Metals
Non-Metallic Minerals
Transport Equipment
Machinery
Mining and Quarrying
Food and Tobacco
Paper, Pulp and Print
Wood and Wood Products
Construction
Textile and Leather
Non-specified (Industry)
Transport Sector
International Civil Aviation
Domestic Air Transport
Road
Rail
Pipeline Transport
Internal Navigation
Non-specified (Transport)
Other Sectors
Agriculture
Commerce and Public Services
Residential
Non-specified (Other)

(vii) Non-energy use of fuels

Some fuels are used for purposes other than as a supply of energy. For example, coal, oil or gas may be used as a chemical feedstock. Some oil products may be used for lubrication purposes or as industrial solvents. The energy consumption table needs to make provision for this use of fuel. The sectors included in this section of the table are indicated in Table 6.5.

Table 6.5: Non-energy use elements

Non-Energy Use in Industrial, Transformation and Energy Non-Energy Use in Transport Non-Energy Use in Other Sectors Feedstock Use in Petrochemical Industry.

A complete basic energy consumption table for South Africa for 1997 is given in Table 6.6. It was extracted from the prototype system.

6.3.1.2 Energy Balances

An energy balance is essentially an input-output table in which energy flows across the economy are tracked and tabulated. The WEC (1992:70) defines an energy balance as: "A balance showing in a consistent accounting framework the production, transformation and final consumption of all forms of energy for a given geographic zone and a given period of time, with the quantities expressed in terms of a single accounting unit for purposes of comparison and aggregation".

There are a number of methods used to compile energy balances (Kotzé, 1970; UK, 1977). The format enjoying international recognition is that developed by the IEA (1997b). In the interest of uniformity, this format is proposed as the standard that should be used for SA.

The IEA balance can be divided into two distinct forms - an aggregated balance and a disaggregated balance. As the disaggregated balance is the precursor for the aggregated balance, it is appropriate to discuss this first. The IEA does not normally publish the energy balance in disaggregated form, but it is a useful depiction of energy consumption for a national energy information system. All fuels are included using a common unit of measure.

Table 6.6: Energy consumption table - 1996

	Last Updated:	28-Aug-1998		Spreadsheet compiled on:	5-Aug-1999							
RSA 1996	**HARDCOAL**	**BROWN**	**COKCOAL**	**BITCOAL**	**SUBCOAL**	**LIGNITE**	**PEAT**	**PATFUEL**	**OVENCOKE**	**GASCOKE**	**BKB**	**GASWKSGS**
Indigenous Production	206362033.00		3532554.00	202829479.00					2839291.00			29965.33
From Other Sources												
Import	425493.00		425493.00									
Export	-60224402.00			-60224402.00								
Intl. Marine Bunkers												
Stock Changes	2836869.00			2836869.00								
Domestic Supply	**149399993.00**		**3958047.00**	**145441946.00**					**2839291.00**			**29965.33**
Transfers												
Statistical Differences	-766356.00	-	-	-766356.00	-	-	-	-	-	-	-	-0.01
Transformation Sector	**128359175.00**		**3958047.00**	**124401128.00**					**1154409.00**			
Public Electricity Plant	87213899.00			87213899.00								
Autoproducer Electricity Plant	3679000.00			3679000.00								
Public CHP Plant												
Autoproducer CHP Plant												
Public Heat Plant												
Autoproducer Heat Plant												
Heat pumps												
Electric Boilers												
Patent Fuel Plants												
Coke Ovens	3958047.00		3958047.00									
Gas Works	4982229.00			4982229.00								
For Blast Furnace Gas									1154409.00			
Petrochemical Industry												
For BKB												
Oil Refineries												
Liquefaction	28526000.00			28526000.00								
Non-specified (Transformation)												
Energy Sector												**53.33**
Coal Mines												
Oil and Gas Extraction												
Patent Fuel Plants												
Coke Ovens												
Gas Works												
BKB												
Oil Refineries												53.33
Ownuse in Elec., CHP and Heat plant												
Used for Pump Storage												
Nuclear Industry												
Non-specified (Energy)												
Distribution Losses												
Final Consumption	**21807174.00**			**21807174.00**					**1684882.00**			**29912.01**
Industry Sector	**18039225.00**			**18039225.00**					**1684882.00**			**28588.24**
Iron and Steel	2708989.00			2708989.00					1408192.00			10747.68
Chemical and Petrochemical	9290357.00			9290357.00								2866.32
Non-Ferrous Metals												972.05
Non-Metallic Minerals	1205557.00			1205557.00								5739.52
Transport Equipment												201.23
Machinery												4733.78
Mining and Quarrying	554578.00			554578.00								325.00
Food and Tobacco												949.06
Paper Pulp and Print												387.97
Wood and Wood Products												271.23
Construction												
Textile and Leather												101.30
Non-specified (Industry)	4279744.00			4279744.00					276690.00			1293.10
Transport Sector	**23402.00**			**23402.00**								**13.91**
International Civil Aviation												
Domestic Air Transport												13.91
Road												
Rail	23402.00			23402.00								
Pipeline Transport												
Internal Navigation												
Non-specified (Transport)												
Other Sectors	**3744547.00**			**3744547.00**								**1309.86**
Agriculture	242211.00			242211.00								
Commerce and Public Services	1302336.00			1302336.00								839.45
Residential	2200000.00			2200000.00								470.41
Non-specified (Other)												
Non-Energy Use												
Memo:Non-Energy Use Ind/Transf/En												
Memo:Non-Energy Use in Transport												
Memo:Non-Energy Use in Oth.Sect.												
Memo:Feedst.Use in Petchem. Ind.	7625000.00			7625000.00								
Elect.Output in GWh	**184952.00**			**184952.00**								
Elect.Output-public elec. plant	179551.00			179551.00								
Elect.Output-autoprod. elec. plant	5401.00			5401.00								
Elect.Output-public CHP plant												
Elect.Output-autoprod. CHP plant												
Heat Output-public CHP plant												
Heat Output-autoproducer CHP plant												
Heat Output-public heat plant												
Heat Output-autoprod. heat plant												
Heat Output in TJ												
Pumped Hydro Production												
Memo: Gas vented												
Memo: Gas flared												
Memo: Energy use for Gold Mining												
Memo: Energy use for Other Mining												
Memo: Coal from underground operations												

RSA 1996	COKEOVGS	BLFURGS	OXYSTGS	COMRENEW	SBIOMASS	INDWASTE	MUNWASTE	GLBIO	NATGAS	CRNGFEED	CRUDEOIL	NGL	REFFEEDS
Indigenous Production	22937.00	32208.00		429632.00	429632.00				71814.00	392688.00		392688.00	
From Other Sources													
Import										13972188.00	13972188.00		
Export													
Intl. Marine Bunkers													
Stock Changes										1461773.79	1461773.79		
Domestic Supply	**22937.00**	**32208.00**		**429632.00**	**429632.00**				**71814.00**	**15826649.79**	**15433961.79**	**392688.00**	
Transfers													
Statistical Differences	4.00	7361.00	-	-	-	-	-	-	-	0.00	0.00	-	-
Transformation Sector				**29632.00**	**29632.00**				**71814.00**	**15826649.79**	**15433961.79**	**392688.00**	
Public Electricity Plant													
Autoproducer Electricity Plant													
Public CHP Plant													
Autoproducer CHP Plant				29632.00	29632.00								
Public Heat Plant													
Autoproducer Heat Plant													
Heat pumps													
Electric Boilers													
Patent Fuel Plants													
Coke Ovens													
Gas Works													
For Blast Furnace Gas													
Petrochemical Industry													
For BKB													
Oil Refineries										23078121.59	15433961.79	392688.00	
Liquefaction									71814.00	-7251471.80			
Non-specified (Transformation)													
Energy Sector													
Coal Mines													
Oil and Gas Extraction													
Patent Fuel Plants													
Coke Ovens													
Gas Works													
BKB													
Oil Refineries													
Ownuse in Elec., CHP and Heat plant													
Used for Pump Storage													
Nuclear Industry													
Non-specified (Energy)													
Distribution Losses													
Final Consumption	**22933.00**	**24847.00**		**400000.00**	**400000.00**								
Industry Sector	**22933.00**	**24847.00**											
Iron and Steel	22933.00	24847.00											
Chemical and Petrochemical													
Non-Ferrous Metals													
Non-Metallic Minerals													
Transport Equipment													
Machinery													
Mining and Quarrying													
Food and Tobacco													
Paper Pulp and Print													
Wood and Wood Products													
Construction													
Textile and Leather													
Non-specified (Industry)													
Transport Sector													
International Civil Aviation													
Domestic Air Transport													
Road													
Rail													
Pipeline Transport													
Internal Navigation													
Non-specified (Transport)													
Other Sectors				**400000.00**	**400000.00**								
Agriculture													
Commerce and Public Services													
Residential													
Non-specified (Other)				400000.00	400000.00								
Non-Energy Use													
Memo:Non-Energy Use Ind/Transf/En													
Memo:Non-Energy Use in Transport													
Memo:Non-Energy Use in Oth.Sect.													
Memo:Feedst.Use in Petchem. Ind.													
Elect.Output in GWh				**300.00**	**300.00**								
Elect.Output-public elec. plant													
Elect.Output-autoprod. elec. plant													
Elect.Output-public CHP plant													
Elect.Output-autoprod. CHP plant				300.00	300.00								
Heat Output-public CHP plant													
Heat Output-autoproducer CHP plant													
Heat Output-public heat plant													
Heat Output-autoprod. heat plant													
Heat Output in TJ													
Pumped Hydro Production													
Memo: Gas vented													
Memo: Gas flared	4.00	7361.00											
Memo: Energy use for Gold Mining													
Memo: Energy use for Other Mining													
Memo: Coal from underground operati													

RSA 1996	ADDITIVE	NONCRUDE	REFINGAS	ETHANE	LPG	MOTORGAS	AVGAS	JETGAS	JETKERO	OTHKERO	GASDIES	RESFUEL	NAPHTHA
Indigenous Production					472645.26	10844193.16	146723.66		1805984.17	1136998.04	7961506.95	3710209.17	
From Other Sources													
Import						630213.09	18591.44		37374.63	37374.63	267282.90	93062.27	
Export						-907651.40	-140158.16		-242352.61	-242352.61	-2007313.13	-231470.43	
Intl. Marine Bunkers											-411839.00	-2852076.00	
Stock Changes													
Domestic Supply					**472645.26**	**10566754.85**	**25156.94**		**1601006.18**	**932020.05**	**5809637.71**	**719725.00**	
Transfers													
Statistical Differences	-	-	-	-	-	0.00	-0.00	-	-0.00	0.00	0.00	-	-
Transformation Sector													
Public Electricity Plant													
Autoproducer Electricity Plant													
Public CHP Plant													
Autoproducer CHP Plant													
Public Heat Plant													
Autoproducer Heat Plant													
Heat pumps													
Electric Boilers													
Patent Fuel Plants													
Coke Ovens													
Gas Works													
For Blast Furnace Gas													
Petrochemical Industry													
For BKB													
Oil Refineries		7251471.80											
Liquefaction		-7251471.80											
Non-specified (Transformation)													
Energy Sector													
Coal Mines													
Oil and Gas Extraction													
Patent Fuel Plants													
Coke Ovens													
Gas Works													
BKB													
Oil Refineries													
Ownuse in Elec., CHP and Heat plant													
Used for Pump Storage													
Nuclear Industry													
Non-specified (Energy)													
Distribution Losses													
Final Consumption					**472645.26**	**10566754.85**	**25156.94**		**1601006.18**	**932020.05**	**5809637.71**	**719725.00**	
Industry Sector					**214052.36**	**9143.51**				**161335.11**	**813001.62**	**719725.00**	
Iron and Steel													
Chemical and Petrochemical													
Non-Ferrous Metals													
Non-Metallic Minerals													
Transport Equipment													
Machinery													
Mining and Quarrying					4036.53					9283.83	478376.69		
Food and Tobacco													
Paper Pulp and Print													
Wood and Wood Products													
Construction					1434.17	9143.51				13375.35	334624.93		
Textile and Leather													
Non-specified (Industry)					208581.66					138675.94		719725.00	
Transport Sector					**476.63**	**10470894.79**	**25156.94**		**1601006.18**	**15909.79**	**3511725.54**		
International Civil Aviation									855712.80				
Domestic Air Transport							25156.94		745293.37				
Road						10467733.69					3315350.59		
Rail											196374.95		
Pipeline Transport													
Internal Navigation													
Non-specified (Transport)					476.64	3161.10				15909.79			
Other Sectors					**258116.27**	**86716.55**				**754775.15**	**1484910.55**		
Agriculture					28275.69	86716.55				69591.20	1481757.65		
Commerce and Public Services					86957.53					2818.27			
Residential					142883.05					682365.68			
Non-specified (Other)											3152.90		
Non-Energy Use													
Memo:Non-Energy Use Ind/Transf/En													
Memo:Non-Energy Use in Transport													
Memo:Non-Energy Use in Oth.Sect.													
Memo:Feedst.Use in Petchem. Ind.													
Elect.Output in GWh													
Elect.Output-public elec. plant													
Elect.Output-autoprod. elec. plant													
Elect.Output-public CHP plant													
Elect.Output-autoprod. CHP plant													
Heat Output-public CHP plant													
Heat Output-autoproducer CHP plant													
Heat Output-public heat plant													
Heat Output-autoprod. heat plant													
Heat Output in TJ													
Pumped Hydro Production													
Memo: Gas vented													
Memo: Gas flared													
Memo: Energy use for Gold Mining													
Memo: Energy use for Other Mining													
Memo: Coal from underground operati													

RSA 1996	WHITESP	LUBRIC	BITUMEN	PARWAX	PETCOKE	ONONSPEC	NONSPEC	NUCLEAR	HYDRO	GEOTHERM	SOLAR	TIDE	WIND	HEATPUMP
Indigenous Production	144484.00	427436.94	272318.00	33231.00										
From Other Sources														
Import		121081.84				15513.31								
Export		-192196.78												
Intl. Marine Bunkers		-20293.00												
Stock Changes														
Domestic Supply	**144484.00**	**336029.00**	**272318.00**	**33231.00**		**15513.31**								
Transfers														
Statistical Differences	-	-	-	-	-	15513.31	-	-	-	-	-	-	-	-
Transformation Sector														
Public Electricity Plant														
Autoproducer Electricity Plant														
Public CHP Plant														
Autoproducer CHP Plant														
Public Heat Plant														
Autoproducer Heat Plant														
Heat pumps														
Electric Boilers														
Patent Fuel Plants														
Coke Ovens														
Gas Works														
For Blast Furnace Gas														
Petrochemical Industry														
For BKB														
Oil Refineries														
Liquefaction														
Non-specified (Transformation)														
Energy Sector														
Coal Mines														
Oil and Gas Extraction														
Patent Fuel Plants														
Coke Ovens														
Gas Works														
BKB														
Oil Refineries														
Ownuse in Elec., CHP and Heat plant														
Used for Pump Storage														
Nuclear Industry														
Non-specified (Energy)														
Distribution Losses														
Final Consumption	**144484.00**	**336029.00**	**272318.00**	**33231.00**										
Industry Sector														
Iron and Steel														
Chemical and Petrochemical														
Non-Ferrous Metals														
Non-Metallic Minerals														
Transport Equipment														
Machinery														
Mining and Quarrying														
Food and Tobacco														
Paper Pulp and Print														
Wood and Wood Products														
Construction														
Textile and Leather														
Non-specified (Industry)														
Transport Sector														
International Civil Aviation														
Domestic Air Transport														
Road														
Rail														
Pipeline Transport														
Internal Navigation														
Non-specified (Transport)														
Other Sectors														
Agriculture														
Commerce and Public Services														
Residential														
Non-specified (Other)														
Non-Energy Use	**144484.00**	**336029.00**	**272318.00**	**33231.00**										
Memo:Non-Energy Use Ind/Transf/En	144484.00	336029.00	272318.00	33231.00										
Memo:Non-Energy Use in Transport														
Memo:Non-Energy Use in Oth.Sect.														
Memo:Feedst.Use in Petchem. Ind.														
Elect.Output in GWh								**11775.00**	**3539.00**					
Elect.Output-public elec. plant								11775.00	3539.00					
Elect.Output-autoprod. elec. plant														
Elect.Output-public CHP plant														
Elect.Output-autoprod. CHP plant														
Heat Output-public CHP plant														
Heat Output-autoproducer CHP plant														
Heat Output-public heat plant														
Heat Output-autoprod. heat plant														
Heat Output in TJ														
Pumped Hydro Production									2220.00					
Memo: Gas vented														
Memo: Gas flared														
Memo: Energy use for Gold Mining														
Memo: Energy use for Other Mining														
Memo: Coal from underground operati														

RSA 1996	BOILER	OTHER	ELECTR	HEAT
Indigenous Production			200092000.00	
From Other Sources				
Import			29000.00	
Export			-5579000.00	
Intl. Marine Bunkers				
Stock Changes				
Domestic Supply			**194542000.00**	
Transfers				
Statistical Differences	-	-	-1112456.40	-
Transformation Sector				
Public Electricity Plant				
Autoproducer Electricity Plant				
Public CHP Plant				
Autoproducer CHP Plant				
Public Heat Plant				
Autoproducer Heat Plant				
Heat pumps				
Electric Boilers				
Patent Fuel Plants				
Coke Ovens				
Gas Works				
For Blast Furnace Gas				
Petrochemical Industry				
For BKB				
Oil Refineries				
Liquefaction				
Non-specified (Transformation)				
Energy Sector			**31759265.04**	
Coal Mines			2732375.58	
Oil and Gas Extraction				
Patent Fuel Plants				
Coke Ovens				
Gas Works				
BKB				
Oil Refineries			13422889.46	
Ownuse in Elec., CHP and Heat plant			12562600.00	
Used for Pump Storage			3041400.00	
Nuclear Industry				
Non-specified (Energy)				
Distribution Losses			15294163.00	
Final Consumption			**148601028.36**	
Industry Sector			**89829261.88**	
Iron and Steel			15629859.88	
Chemical and Petrochemical			2524255.44	
Non-Ferrous Metals			13045785.24	
Non-Metallic Minerals			1143354.75	
Transport Equipment			8784.62	
Machinery			114942.79	
Mining and Quarrying			34831398.63	
Food and Tobacco			502518.38	
Paper Pulp and Print			968747.09	
Wood and Wood Products			590434.39	
Construction			15581.93	
Textile and Leather			490963.22	
Non-specified (Industry)			19962635.53	
Transport Sector			**4274333.74**	
International Civil Aviation				
Domestic Air Transport			12890.18	
Road			7538.56	
Rail			3446194.68	
Pipeline Transport			59092.41	
Internal Navigation				
Non-specified (Transport)			748617.93	
Other Sectors			**54497432.74**	
Agriculture			5103079.52	
Commerce and Public Services			19806239.62	
Residential			29588113.61	
Non-specified (Other)				
Non-Energy Use				
Memo:Non-Energy Use Ind/Transf/En				
Memo:Non-Energy Use in Transport				
Memo:Non-Energy Use in Oth.Sect.				
Memo:Feedst.Use in Petchem. Ind.				
Elect.Output in GWh			**200566.00**	
Elect.Output-public elec. plant			194865.00	
Elect.Output-autoprod. elec. plant			5401.00	
Elect.Output-public CHP plant				
Elect.Output-autoprod. CHP plant			300.00	
Heat Output-public CHP plant				
Heat Output-autoproducer CHP plant				
Heat Output-public heat plant				
Heat Output-autoprod. heat plant				
Heat Output in TJ				
Pumped Hydro Production			2220.00	
Memo: Gas vented				
Memo: Gas flared			7365.00	
Memo: Energy use for Gold Mining				
Memo: Energy use for Other Mining				
Memo: Coal from underground operati				

(i) Disaggregated balance

The disaggregated balance is in the same layout as for the basic consumption data discussed in the previous section. Instead of presenting the information in different units of measurement however, a single common energy unit is used. A number of different units can be utilised but all have one factor in common – they measure the energy content of the individual fuels and present it using a single unit of measurement. The IEA generally presents balances in tonnes of oil equivalent (toe), an energy measurement equal to 41,868 GJ (IEA, 1997b:ix). The EIA prefers to use "quads" or quadrillion Btu (the equivalent of 1055 PJ (10^{15} J)), as the common unit in their publications (EIA, 1996c:3,5). The energy unit specified in the SI system is the joule (J) and its multiples. In South Africa the terajoule (1 TJ = 10^{12} J) is commonly used as the energy accounting unit measure.

The disaggregated energy balance is calculated by multiplying each element of the basic energy consumption table by the appropriate calorific value, to produce the balance in a single unit of measurement. The calorific values used are given in Table 6.7, while the disaggregated balance for South Africa for 1997 is given in Table 6.8.

Table 6.7: Calorific values for fuels

Fuel	Calorific value	Units	Density
Electricity	3.6	MJ/kWh	
Natural gas	41.0	MJ/m³	
LPG	26.7	MJ/*l*	0.541
Petrol	34.2	MJ/*l*	0.723
Avgas	33.9	MJ/*l*	0.730
Illuminating paraffin	37.0	MJ/*l*	0.788
Power paraffin	37.5	MJ/*l*	0.813
Jet fuel (kerosene type)	34.3	MJ/*l*	0.793
Jet fuel (gasoline type)	34.0	MJ/*l*	0.730
Diesel	38.1	MJ/*l*	0.839
HFO	41.6	MJ/*l*	0.984
Coal (Public electricity)	20.1	MJ/kg	
Coal (Liquefaction)	21.9	MJ/kg	
Coal (general purpose)	27.0	MJ/kg	
Coal (coking)	30.1	MJ/kg	
Coal (export)	28.0	MJ/kg	
Coke	27.9	MJ/kg	
Coke oven gas	17.3	MJ/m³	
Blast furnace gas	3.1	MJ/m³	
Bagasse (wet)	7.0	MJ/kg	
Bagasse fibre (dry)	14.0	MJ/kg	
Biomass (dry wood - typical)	17.0	MJ/kg	
Coal gas (Sasol - hydrogen rich)	18.0	MJ/m³	
Coal gas (Sasol - methane rich)	38.0	MJ/m³	
Crude oil (average)	42.7	MJ/kg	
Natural gas liquids	45.0	MJ/kg	
Naphtha	35.0	MJ/*l*	
White spirits	40.2	MJ/*l*	
Lubricants	40.2	MJ/kg	
Bitumen	40.2	MJ/kg	
Paraffin waxes	40.2	MJ/kg	
Petroleum coke	40.2	MJ/kg	

Table 6.8: Disaggregated balance - 1996

RSA 1996	Last Updated on:	28-Aug-1998		This Sheet Compiled on:	5-Aug-1999						
(TJ)	Hard Coal	Brown Coal	Coking Coal	Bituminous Coal	Sub-Bituminous Coal	Lignite	Peat	Patent Fuel	Coke oven coke	Gas Coke	BKB
Indigenous Production	4,896,284.88	-	109,509.17	4,786,775.70	-	-	-	-	-	-	-
From Other Sources	-	-	-	-	-	-	-	-	-	-	-
Import	13,190.28	-	13,190.28	-	-	-	-	-	-	-	-
Export	-1,686,283.26	-	-	-1,686,283.26	-	-	-	-	-	-	-
Intl. Marine Bunkers	-	-	-	-	-	-	-	-	-	-	-
Stock Changes	76,595.46	-	-	76,595.46	-	-	-	-	-	-	-
Domestic Supply	**3,299,787.37**	-	**122,699.46**	**3,177,087.91**	-	-	-	-	-	-	-
Transfers	-	-	-	-	-	-	-	-	-	-	-
Statistical Differences	23,277.74	-	-	23,277.74	-	-	-	-	-0.00	-	-
Transformation Sector	**-2,734,271.41**	-	**-122,699.46**	**-2,611,571.95**	-	-	-	-	**47,008.21**	-	-
Public Electricity Plant	-1,752,999.37	-	-	-1,752,999.37	-	-	-	-	-	-	-
Autoproducer Electricity Plant	-99,333.00	-	-	-99,333.00	-	-	-	-	-	-	-
Public CHP Plant	-	-	-	-	-	-	-	-	-	-	-
Autoproducer CHP Plant	-	-	-	-	-	-	-	-	-	-	-
Public Heat Plant	-	-	-	-	-	-	-	-	-	-	-
Autoproducer Heat Plant	-	-	-	-	-	-	-	-	-	-	-
Heat pumps	-	-	-	-	-	-	-	-	-	-	-
Electric Boilers	-	-	-	-	-	-	-	-	-	-	-
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-122,699.46	-	-122,699.46	-	-	-	-	-	79,216.22	-	-
Gas Works	-134,520.18	-	-	-134,520.18	-	-	-	-	-	-	-
For Blast Furnace Gas	-	-	-	-	-	-	-	-	-32,208.01	-	-
Petrochemical Industry	-	-	-	-	-	-	-	-	-	-	-
For BKB	-	-	-	-	-	-	-	-	-	-	-
Oil Refineries	-	-	-	-	-	-	-	-	-	-	-
Liquefaction	-624,719.40	-	-	-624,719.40	-	-	-	-	-	-	-
Non-specified (Transformation)	-	-	-	-	-	-	-	-	-	-	-
Energy Sector	-	-	-	-	-	-	-	-	-	-	-
Coal Mines	-	-	-	-	-	-	-	-	-	-	-
Oil and Gas Extraction	-	-	-	-	-	-	-	-	-	-	-
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-
Gas Works	-	-	-	-	-	-	-	-	-	-	-
BKB	-	-	-	-	-	-	-	-	-	-	-
Oil Refineries	-	-	-	-	-	-	-	-	-	-	-
Ownuse in Elec., CHP and Heat pl	-	-	-	-	-	-	-	-	-	-	-
Used for Pump Storage	-	-	-	-	-	-	-	-	-	-	-
Nuclear Industry	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Energy)	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Distribution Losses	-	-	-	-	-	-	-	-	-	-	-
Final Consumption	**588,793.70**	-	-	**588,793.70**	-	-	-	-	**47,008.21**	-	-
Industry Sector	487,059.08	-	-	487,059.08	-	-	-	-	47,008.21	-	-
Iron and Steel	73,142.70	-	-	73,142.70	-	-	-	-	39,288.56	-	-
Chemical and Petrochemical	250,839.64	-	-	250,839.64	-	-	-	-	-	-	-
Non-Ferrous Metals	-	-	-	-	-	-	-	-	-	-	-
Non-Metallic Minerals	32,550.04	-	-	32,550.04	-	-	-	-	-	-	-
Transport Equipment	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	-	-	-	-	-	-	-	-	-	-
Mining and Quarrying	14,973.61	-	-	14,973.61	-	-	-	-	-	-	-
Food and Tobacco	-	-	-	-	-	-	-	-	-	-	-
Paper Pulp and Print	-	-	-	-	-	-	-	-	-	-	-
Wood and Wood Products	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-	-	-	-	-
Textile and Leather	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Industry)	115,553.09	-	-	115,553.09	-	-	-	-	7,719.65	-	-
Transport Sector	**631.85**	-	-	**631.85**	-	-	-	-	-	-	-
International Civil Aviation	-	-	-	-	-	-	-	-	-	-	-
Domestic Air Transport	-	-	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	-	-	-	-
Rail	631.85	-	-	631.85	-	-	-	-	-	-	-
Pipeline Transport	-	-	-	-	-	-	-	-	-	-	-
Internal Navigation	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Transport)	-	-	-	-	-	-	-	-	-	-	-
Other Sectors	**101,102.77**	-	-	**101,102.77**	-	-	-	-	-	-	-
Agriculture	6,539.70	-	-	6,539.70	-	-	-	-	-	-	-
Commerce and Public Services	35,163.07	-	-	35,163.07	-	-	-	-	-	-	-
Residential	59,400.00	-	-	59,400.00	-	-	-	-	-	-	-
Non-specified (Other)	-	-	-	-	-	-	-	-	-	-	-
Non-Energy Use	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use Ind/Transf/	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use in Transpo	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use in Oth.Sec	-	-	-	-	-	-	-	-	-	-	-
Memo:Feedst.Use in Petchem. Ind	205,875.00	-	-	205,875.00	-	-	-	-	-	-	-
Elect.Output in GWh	**184,952.00**	-	-	**184,952.00**	-	-	-	-	-	-	-
Elect.Output-public elec. plant	179,551.00	-	-	179,551.00	-	-	-	-	-	-	-
Elect.Output-autoprod. elec. plant	5,401.00	-	-	5,401.00	-	-	-	-	-	-	-
Elect.Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. CHP plant	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoproducer CHP pla	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public heat plant	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoprod. heat plant	-	-	-	-	-	-	-	-	-	-	-
Heat Output in TJ	-	-	-	-	-	-	-	-	-	-	-
Pumped Hydro Production	-	-	-	-	-	-	-	-	-	-	-
Memo: Gas vented	-	-	-	-	-	-	-	-	-	-	-
Memo: Gas flared	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Gold Mining	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Other Minin	-	-	-	-	-	-	-	-	-	-	-

RSA 1996 (TJ)	Gasworks Gas	Coke oven Gas	Blast Furnace Gas	Oxygen Furnace Gas	Renewables & Waste	SBIOMASS	Industrial Waste	Municipal Waste	GLBIO	Natural Gas	Crude + NGLs + Feedstocks	Crude Oil
Indigenous Production	-	-	-	-	429,632.00	429,632.00	-	-	-	71,814.00	17,670.96	-
From Other Sources	-	-	-	-	-	-	-	-	-	-	-	-
Import	-	-	-	-	-	-	-	-	-	-	596,053.54	596,053.54
Export	-	-	-	-	-	-	-	-	-	-	-	-
Intl. Marine Bunkers	-	-	-	-	-	-	-	-	-	-	-	-
Stock Changes	-	-	-	-	-	-	-	-	-	-	62,359.27	62,359.27
Domestic Supply	-	-	-	-	429,632.00	429,632.00	-	-	-	71,814.00	676,083.77	658,412.81
Transfers	-	-	-	-	-	-	-	-	-	-	-	-
Statistical Differences	0.01	-4.00	-7,361.00	-	-	-	-	-	-	-	-0.00	-0.00
Transformation Sector	29,965.33	22,937.00	32,208.00	-	-29,632.00	-29,632.00	-	-	-	-71,814.00	-676,083.77	-658,412.81
Public Electricity Plant	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer Electricity Plant	-	-	-	-	-	-	-	-	-	-	-	-
Public CHP Plant	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer CHP Plant	-	-	-	-	-29,632.00	-29,632.00	-	-	-	-	-	-
Public Heat Plant	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer Heat Plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat pumps	-	-	-	-	-	-	-	-	-	-	-	-
Electric Boilers	-	-	-	-	-	-	-	-	-	-	-	-
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	22,937.00	-	-	-	-	-	-	-	-	-	-
Gas Works	29,965.33	-	-	-	-	-	-	-	-	-	-	-
For Blast Furnace Gas	-	-	32,208.00	-	-	-	-	-	-	-	-	-
Petrochemical Industry	-	-	-	-	-	-	-	-	-	-	-	-
For BKB	-	-	-	-	-	-	-	-	-	-	-	-
Oil Refineries	-	-	-	-	-	-	-	-	-	-	-985,431.56	-658,412.81
Liquefaction	-	-	-	-	-	-	-	-	-	-71,814.00	309,347.79	-
Non-specified (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-
Energy Sector	-53.33	-	-	-	-	-	-	-	-	-	-	-
Coal Mines	-	-	-	-	-	-	-	-	-	-	-	-
Oil and Gas Extraction	-	-	-	-	-	-	-	-	-	-	-	-
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-	-
Gas Works	-	-	-	-	-	-	-	-	-	-	-	-
BKB	-	-	-	-	-	-	-	-	-	-	-	-
Oil Refineries	-53.33	-	-	-	-	-	-	-	-	-	-	-
Ownuse in Elec., CHP and Heat pla	-	-	-	-	-	-	-	-	-	-	-	-
Used for Pump Storage	-	-	-	-	-	-	-	-	-	-	-	-
Nuclear Industry	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Energy)	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Distribution Losses	-	-	-	-	-	-	-	-	-	-	-	-
Final Consumption	29,912.01	22,933.00	24,847.00	-	400,000.00	400,000.00	-	-	-	-	-	-
Industry Sector	28,588.24	22,933.00	24,847.00	-	-	-	-	-	-	-	-	-
Iron and Steel	10,747.68	22,933.00	24,847.00	-	-	-	-	-	-	-	-	-
Chemical and Petrochemical	2,866.32	-	-	-	-	-	-	-	-	-	-	-
Non-Ferrous Metals	972.05	-	-	-	-	-	-	-	-	-	-	-
Non-Metallic Minerals	5,739.52	-	-	-	-	-	-	-	-	-	-	-
Transport Equipment	201.23	-	-	-	-	-	-	-	-	-	-	-
Machinery	4,733.78	-	-	-	-	-	-	-	-	-	-	-
Mining and Quarrying	325.00	-	-	-	-	-	-	-	-	-	-	-
Food and Tobacco	949.06	-	-	-	-	-	-	-	-	-	-	-
Paper Pulp and Print	387.97	-	-	-	-	-	-	-	-	-	-	-
Wood and Wood Products	271.23	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-	-	-	-	-	-
Textile and Leather	101.30	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Industry)	1,293.10	-	-	-	-	-	-	-	-	-	-	-
Transport Sector	13.91	-	-	-	-	-	-	-	-	-	-	-
International Civil Aviation	-	-	-	-	-	-	-	-	-	-	-	-
Domestic Air Transport	13.91	-	-	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	-	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-	-	-	-
Pipeline Transport	-	-	-	-	-	-	-	-	-	-	-	-
Internal Navigation	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Transport)	-	-	-	-	-	-	-	-	-	-	-	-
Other Sectors	1,309.86	-	-	-	400,000.00	400,000.00	-	-	-	-	-	-
Agriculture	-	-	-	-	-	-	-	-	-	-	-	-
Commerce and Public Services	839.45	-	-	-	-	-	-	-	-	-	-	-
Residential	470.41	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Other)	-	-	-	-	400,000.00	400,000.00	-	-	-	-	-	-
Non-Energy Use	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use Ind/Transf/	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use in Transpo	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use in Oth.Sect	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Feedst.Use in Petchem. Ind	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output in GWh	-	-	-	-	300.00	300.00	-	-	-	-	-	-
Elect.Output-public elec. plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. elec. plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. CHP plant	-	-	-	-	300.00	300.00	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoproducer CHP pla	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public heat plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoprod. heat plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output in TJ	-	-	-	-	-	-	-	-	-	-	-	-
Pumped Hydro Production	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Gas vented	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Gas flared	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Gold Mining	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Other Minin	-	-	-	-	-	-	-	-	-	-	-	-

RSA 1996 (TJ)	NGLs	Refinery Feedstocks	Additives	Non-Conventional Crude	Refinery Gas	Ethane	LPG	Motor Gasoline	Aviation Gasoline	Jet Gasoline	Jet Kerosene	Other Kerosene
Indigenous Production	17,670.96	-	-	-	-	-	-	-	-	-	-	-
From Other Sources	-	-	-	-	-	-	-	-	-	-	-	-
Import	-	-	-	-	-	-	-	21,553.29	630.25	-	1,281.95	1,382.86
Export	-	-	-	-	-	-	-	-31,041.68	-4,751.36	-	-8,312.69	-8,967.05
Intl. Marine Bunkers	-	-	-	-	-	-	-	-	-	-	-	-
Stock Changes	-	-	-	-	-	-	-	-	-	-	-	-
Domestic Supply	**17,670.96**	-	-	-	-	-	-	**-9,488.39**	**-4,121.11**	-	**-7,030.74**	**-7,584.19**
Transfers	-	-	-	-	-	-	-	-	-	-	-	-
Statistical Differences	-	-	-	-	-	-	-0.00	-	0.00	-	0.00	-
Transformation Sector	**-17,670.96**	-	-	-	-	-	**12,619.63**	**370,871.41**	**4,973.93**	-	**61,945.26**	**42,068.93**
Public Electricity Plant	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer Electricity Plant	-	-	-	-	-	-	-	-	-	-	-	-
Public CHP Plant	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer CHP Plant	-	-	-	-	-	-	-	-	-	-	-	-
Public Heat Plant	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer Heat Plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat pumps	-	-	-	-	-	-	-	-	-	-	-	-
Electric Boilers	-	-	-	-	-	-	-	-	-	-	-	-
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-	-
Gas Works	-	-	-	-	-	-	-	-	-	-	-	-
For Blast Furnace Gas	-	-	-	-	-	-	-	-	-	-	-	-
Petrochemical Industry	-	-	-	-	-	-	-	-	-	-	-	-
For BKB	-	-	-	-	-	-	-	-	-	-	-	-
Oil Refineries	-17,670.96	-	-	-309,347.79	-	-	12,619.63	370,871.41	4,973.93	-	61,945.26	42,068.93
Liquefaction	-	-	-	309,347.79	-	-	-	-	-	-	-	-
Non-specified (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-
Energy Sector	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines	-	-	-	-	-	-	-	-	-	-	-	-
Oil and Gas Extraction	-	-	-	-	-	-	-	-	-	-	-	-
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-	-
Gas Works	-	-	-	-	-	-	-	-	-	-	-	-
BKB	-	-	-	-	-	-	-	-	-	-	-	-
Oil Refineries	-	-	-	-	-	-	-	-	-	-	-	-
Ownuse in Elec., CHP and Heat pl	-	-	-	-	-	-	-	-	-	-	-	-
Used for Pump Storage	-	-	-	-	-	-	-	-	-	-	-	-
Nuclear Industry	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Energy)	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Distribution Losses	-	-	-	-	-	-	-	-	-	-	-	-
Final Consumption	-	-	-	-	-	-	**12,619.63**	**361,383.02**	**852.82**	-	**54,914.51**	**34,484.74**
Industry Sector	-	-	-	-	-	-	5,715.20	312.71	-	-	-	5,969.40
Iron and Steel	-	-	-	-	-	-	-	-	-	-	-	-
Chemical and Petrochemical	-	-	-	-	-	-	-	-	-	-	-	-
Non-Ferrous Metals	-	-	-	-	-	-	-	-	-	-	-	-
Non-Metallic Minerals	-	-	-	-	-	-	-	-	-	-	-	-
Transport Equipment	-	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	-	-	-	-	-	-	-	-	-	-	-
Mining and Quarrying	-	-	-	-	-	-	107.77	-	-	-	-	343.50
Food and Tobacco	-	-	-	-	-	-	-	-	-	-	-	-
Paper Pulp and Print	-	-	-	-	-	-	-	-	-	-	-	-
Wood and Wood Products	-	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	38.28	312.71	-	-	-	494.89
Textile and Leather	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Industry)	-	-	-	-	-	-	5,569.12	-	-	-	-	5,131.01
Transport Sector	-	-	-	-	-	-	**12.73**	**358,104.60**	**852.82**	-	**54,914.51**	**588.66**
International Civil Aviation	-	-	-	-	-	-	-	-	-	-	29,350.95	-
Domestic Air Transport	-	-	-	-	-	-	-	-	852.82	-	25,563.56	-
Road	-	-	-	-	-	-	-	357,996.49	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-	-	-	-
Pipeline Transport	-	-	-	-	-	-	-	-	-	-	-	-
Internal Navigation	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Transport)	-	-	-	-	-	-	12.74	108.11	-	-	-	588.66
Other Sectors	-	-	-	-	-	-	**6,891.70**	**2,965.71**	-	-	-	**27,926.68**
Agriculture	-	-	-	-	-	-	754.97	2,965.71	-	-	-	2,574.87
Commerce and Public Services	-	-	-	-	-	-	2,321.77	-	-	-	-	104.28
Residential	-	-	-	-	-	-	3,814.98	-	-	-	-	25,247.53
Non-specified (Other)	-	-	-	-	-	-	-	-	-	-	-	-
Non-Energy Use	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use Ind/Transf	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use in Transpo	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use in Oth.Sec	-	-	-	-	-	-	-	-	-	-	-	-
Memo:Feedst.Use in Petchem. Ind	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output in GWh	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-public elec. plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. elec. plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoproducer CHP pla	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public heat plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoprod. heat plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output in TJ	-	-	-	-	-	-	-	-	-	-	-	-
Pumped Hydro Production	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Gas vented	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Gas flared	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Gold Mining	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Other Minin	-	-	-	-	-	-	-	-	-	-	-	-

RSA 1996 (TJ)	Gas Diesel	Residual Fuel	Naphtha	White Spirit	Lubricants	Bitumen	Parrafin Wax	Petroleum Coke	Non-specified oil products	NONSPEC	Nuclear	Hydro
Indigenous Production	-	-	-	-	-	-	-	-	-	-	128,454.55	4,748.40
From Other Sources	-	-	-	-	-	-	-	-	-	-		
Import	10,183.48	3,871.39	-	-	4,867.49	-	-	-	623.63	-		
Export	-76,478.63	-9,629.17	-	-	-7,726.31	-	-	-	-	-		
Intl. Marine Bunkers	-15,691.07	-118,646.36	-	-	-815.78	-	-	-	-	-		
Stock Changes	-	-	-	-	-	-	-	-	-	-		
Domestic Supply	**-81,986.22**	**-124,404.14**	**-**	**-**	**-3,674.60**	**-**	**-**	**-**	**623.63**	**-**	**128,454.55**	**4,748.40**
Transfers	-	-	-	-	-	-	-	-	-	-		
Statistical Differences	0.00	-0.00	-	-	-	-	-	-	-623.63	-	-	-0.00
Transformation Sector	**303,333.41**	**154,344.70**	**-**	**5,808.26**	**17,182.96**	**10,947.18**	**1,335.89**	**-**	**-**	**-**	**-128,454.55**	**-4,748.40**
Public Electricity Plant	-	-	-	-	-	-	-	-	-	-	-128,454.55	-4,748.40
Autoproducer Electricity Plant	-	-	-	-	-	-	-	-	-	-	-	-
Public CHP Plant	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer CHP Plant	-	-	-	-	-	-	-	-	-	-	-	-
Public Heat Plant	-	-	-	-	-	-	-	-	-	-		
Autoproducer Heat Plant	-	-	-	-	-	-	-	-	-	-		
Heat pumps	-	-	-	-	-	-	-	-	-	-		
Electric Boilers	-	-	-	-	-	-	-	-	-	-		
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-		
Coke Ovens	-	-	-	-	-	-	-	-	-	-		
Gas Works	-	-	-	-	-	-	-	-	-	-		
For Blast Furnace Gas	-	-	-	-	-	-	-	-	-	-		
Petrochemical Industry	-	-	-	-	-	-	-	-	-	-		
For BKB	-	-	-	-	-	-	-	-	-	-		
Oil Refineries	303,333.41	154,344.70	-	5,808.26	17,182.96	10,947.18	1,335.89	-	-	-		
Liquefaction	-	-	-	-	-	-	-	-	-	-		
Non-specified (Transformation)	-	-	-	-	-	-	-	-	-	-		
Energy Sector	-	-	-	-	-	-	-	-	-	-		
Coal Mines	-	-	-	-	-	-	-	-	-	-		
Oil and Gas Extraction	-	-	-	-	-	-	-	-	-	-		
Patent Fuel Plants	-	-	-	-	-	-	-	-	-	-		
Coke Ovens	-	-	-	-	-	-	-	-	-	-		
Gas Works	-	-	-	-	-	-	-	-	-	-		
BKB	-	-	-	-	-	-	-	-	-	-		
Oil Refineries	-	-	-	-	-	-	-	-	-	-		
Ownuse in Elec., CHP and Heat pl	-	-	-	-	-	-	-	-	-	-		
Used for Pump Storage	-	-	-	-	-	-	-	-	-	-		
Nuclear Industry	-	-	-	-	-	-	-	-	-	-		
Non-specified (Energy)	-	-	-	-	-	-	-	-	-	-		
	-	-	-	-	-	-	-	-	-	-		
Distribution Losses	-	-	-	-	-	-	-	-	-	-		
Final Consumption	**221,347.20**	**29,940.56**	**-**	**5,808.26**	**13,508.37**	**10,947.18**	**1,335.89**	**-**	**-**	**-**		
Industry Sector	30,975.36	29,940.56	-	-	-	-	-	-	-	-		
Iron and Steel	-	-	-	-	-	-	-	-	-	-		
Chemical and Petrochemical	-	-	-	-	-	-	-	-	-	-		
Non-Ferrous Metals	-	-	-	-	-	-	-	-	-	-		
Non-Metallic Minerals	-	-	-	-	-	-	-	-	-	-		
Transport Equipment	-	-	-	-	-	-	-	-	-	-		
Machinery	-	-	-	-	-	-	-	-	-	-		
Mining and Quarrying	18,226.15	-	-	-	-	-	-	-	-	-		
Food and Tobacco	-	-	-	-	-	-	-	-	-	-		
Paper Pulp and Print	-	-	-	-	-	-	-	-	-	-		
Wood and Wood Products	-	-	-	-	-	-	-	-	-	-		
Construction	12,749.21	-	-	-	-	-	-	-	-	-		
Textile and Leather	-	-	-	-	-	-	-	-	-	-		
Non-specified (Industry)	-	29,940.56	-	-	-	-	-	-	-	-		
Transport Sector	**133,796.74**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**		
International Civil Aviation	-	-	-	-	-	-	-	-	-	-		
Domestic Air Transport	-	-	-	-	-	-	-	-	-	-		
Road	126,314.86	-	-	-	-	-	-	-	-	-		
Rail	7,481.89	-	-	-	-	-	-	-	-	-		
Pipeline Transport	-	-	-	-	-	-	-	-	-	-		
Internal Navigation	-	-	-	-	-	-	-	-	-	-		
Non-specified (Transport)	-	-	-	-	-	-	-	-	-	-		
Other Sectors	**56,575.09**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**		
Agriculture	56,454.97	-	-	-	-	-	-	-	-	-		
Commerce and Public Services	-	-	-	-	-	-	-	-	-	-		
Residential	-	-	-	-	-	-	-	-	-	-		
Non-specified (Other)	120.13	-	-	-	-	-	-	-	-	-		
Non-Energy Use	-	-	-	**5,808.26**	**13,508.37**	**10,947.18**	**1,335.89**	-	-	-		
Memo:Non-Energy Use Ind/Transf/	-	-	-	5,808.25	13,508.36	10,947.20	1,335.89	-	-	-		
Memo:Non-Energy Use in Transpo	-	-	-	-	-	-	-	-	-	-		
Memo:Non-Energy Use in Oth.Sec	-	-	-	-	-	-	-	-	-	-		
Memo:Feedst.Use in Petchem. Ind	-	-	-	-	-	-	-	-	-	-		
Elect.Output in GWh	-	-	-	-	-	-	-	-	-	-	**11,775.00**	**1,319.00**
Elect.Output-public elec. plant	-	-	-	-	-	-	-	-	-	-	11,775.00	1,319.00
Elect.Output-autoprod. elec. plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoproducer CHP pla	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public heat plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoprod. heat plant	-	-	-	-	-	-	-	-	-	-	-	-
Heat Output in TJ	-	-	-	-	-	-	-	-	-	-	-	-
Pumped Hydro Production	-	-	-	-	-	-	-	-	-	-	-	2,220.00
Memo: Gas vented	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Gas flared	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Gold Mining	-	-	-	-	-	-	-	-	-	-	-	-
Memo: Energy use for Other Minin	-	-	-	-	-	-	-	-	-	-	-	-

RSA 1996 (TJ)	Geothermal	Solar	Tide	Wind	Heatpumps	Boilers	Other	Electricity	XXX
Indigenous Production	-	-	-	-	-	-	-	714,045.60	-
From Other Sources						-	-	-	-
Import						-	-	104.40	-
Export						-	-	-20,084.40	-
Intl. Marine Bunkers						-	-	-	-
Stock Changes						-	-	-	-
Domestic Supply	-	-	-	-	-	-	-	**694,065.60**	-
Transfers						-	-	-	-
Statistical Differences	-	-	-	-	-	-	-	30,765.95	-
Transformation Sector	-	-	-	-	-	-	-	**-714,045.60**	-
Public Electricity Plant	-	-	-	-	-	-	-	-693,522.00	-
Autoproducer Electricity Plant	-	-	-	-	-	-	-	-19,443.60	-
Public CHP Plant	-	-	-	-	-	-	-	-	-
Autoproducer CHP Plant	-	-	-	-	-	-	-	-1,080.00	-
Public Heat Plant						-	-	-	-
Autoproducer Heat Plant						-	-	-	-
Heat pumps						-	-	-	-
Electric Boilers						-	-	-	-
Patent Fuel Plants						-	-	-	-
Coke Ovens						-	-	-	-
Gas Works						-	-	-	-
For Blast Furnace Gas						-	-	-	-
Petrochemical Industry						-	-	-	-
For BKB						-	-	-	-
Oil Refineries						-	-	-	-
Liquefaction						-	-	-	-
Non-specified (Transformation)						-	-	-	-
Energy Sector						-	-	**-134,808.85**	-
Coal Mines						-	-	-9,836.55	-
Oil and Gas Extraction						-	-	-	-
Patent Fuel Plants						-	-	-	-
Coke Ovens						-	-	-	-
Gas Works						-	-	-	-
BKB						-	-	-	-
Oil Refineries						-	-	-48,322.40	-
Ownuse in Elec., CHP and Heat pl						-	-	-45,225.36	-
Used for Pump Storage						-	-	-31,424.54	-
Nuclear Industry						-	-	-	-
Non-specified (Energy)						-	-	-	-
						-	-	-	-
Distribution Losses						-	-	-55,058.99	-
Final Consumption						-	-	**534,963.70**	-
Industry Sector						-	-	323,385.34	-
Iron and Steel						-	-	56,267.50	-
Chemical and Petrochemical						-	-	9,087.32	-
Non-Ferrous Metals						-	-	46,964.82	-
Non-Metallic Minerals						-	-	4,116.08	-
Transport Equipment						-	-	31.63	-
Machinery						-	-	413.79	-
Mining and Quarrying						-	-	125,393.03	-
Food and Tobacco						-	-	1,809.06	-
Paper Pulp and Print						-	-	3,487.49	-
Wood and Wood Products						-	-	2,125.57	-
Construction						-	-	56.10	-
Textile and Leather						-	-	1,767.47	-
Non-specified (Industry)						-	-	71,865.48	-
Transport Sector						-	-	**15,387.60**	-
International Civil Aviation						-	-	-	-
Domestic Air Transport						-	-	46.41	-
Road						-	-	27.14	-
Rail						-	-	12,406.30	-
Pipeline Transport						-	-	212.73	-
Internal Navigation						-	-	-	-
Non-specified (Transport)						-	-	2,695.04	-
Other Sectors						-	-	**196,190.76**	-
Agriculture						-	-	18,371.08	-
Commerce and Public Services						-	-	71,302.46	-
Residential						-	-	106,517.21	-
Non-specified (Other)						-	-	-	-
Non-Energy Use						-	-	-	-
Memo:Non-Energy Use Ind/Transf/						-	-	-	-
Memo:Non-Energy Use in Transpo						-	-	-	-
Memo:Non-Energy Use in Oth.Sec						-	-	-	-
Memo:Feedst.Use in Petchem. Ind						-	-	-	-
Elect.Output in GWh	-	-	-	-	-	-	-	**198,346.00**	-
Elect.Output-public elec. plant	-	-	-	-	-	-	-	192,645.00	-
Elect.Output-autoprod. elec. plant	-	-	-	-	-	-	-	5,401.00	-
Elect.Output-public CHP plant	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. CHP plant	-	-	-	-	-	-	-	300.00	-
	-	-	-	-	-	-	-	-	-
Heat Output-public CHP plant	-	-	-	-	-	-	-	-	-
Heat Output-autoproducer CHP pla	-	-	-	-	-	-	-	-	-
Heat Output-public heat plant	-	-	-	-	-	-	-	-	-
Heat Output-autoprod. heat plant	-	-	-	-	-	-	-	-	-
Heat Output in TJ	-	-	-	-	-	-	-	-	-
Pumped Hydro Production	-	-	-	-	-	-	-	2,220.00	-
Memo: Gas vented	-	-	-	-	-	-	-	-	-
Memo: Gas flared	-	-	-	-	-	-	-	-	-
Memo: Energy use for Gold Mining	-	-	-	-	-	-	-	-	-
Memo: Energy use for Other Minin	-	-	-	-	-	-	-	-	-

(ii) Aggregated balance

The data encapsulated in the disaggregated balance is very comprehensive, and a requirement to condense this into a more manageable output format exists. The individual fuels data in the disaggregated balance is condensed into logical groupings of data for energy sources, as follows:

- Coal.
- Crude oil.
- Petroleum products.
- Gas.
- Nuclear.
- Hydro.
- Geothermal, solar, etc.
- Renewables and waste.
- Electricity.
- Heat.

The transformation and energy sector components of the disaggregated balance are rationalised into the elements tabulated in Table 6.9.

Table 6.9: Transformation and energy sector elements

Public Electricity Plant
Autoproducer Electricity Plant
Public CHP Plant
Autoproducer CHP Plant
Public Heat Plant
Autoproducer Heat Plant
Heat pumps
Electric boilers
Gas Works
Oil Refineries
Coal Transformation
Liquefaction
Non-specified (Transformation)
Own Use

Table 6.10: Energy balance - 1996

TJ	1996										
	Coal	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Geothermal Solar etc	Renewables & Waste	Electricity	Heat	Total
Indigenous Production	4,896,284.88	17,670.96	-	71,814.00	128,454.55	4,748.40	-	429,632.00	-	-	5,548,604.79
Import	13,190.28	596,053.54	44,394.34	-	-	-	-	-	104.40	-	653,742.56
Export	-1,686,283.26	-	-146,906.88	-	-	-	-	-	-20,084.40	-	-1,853,274.54
Intl. Marine Bunkers	-	-	-135,153.21	-	-	-	-	-	-	-	-135,153.21
Stock Changes	76,595.46	62,359.27	-	-	-	-	-	-	-	-	138,954.73
Total Primary Energy Supply	**3,299,787.37**	**676,083.77**	**-237,665.75**	**71,814.00**	**128,454.55**	**4,748.40**	**-**	**429,632.00**	**-19,980.00**	**-**	**4,352,874.33**
Transfers	-	-	-	-	-	-	-	-	-	-	-
Statistical Differences	15,912.74	-0.00	-623.64	0.01	-	-	-	-	30,765.95	-	46,055.07
Public Electricity Plant	-1,752,999.37	-	-	-	-128,454.55	-4,748.40	-	-	693,522.00	-	-1,192,680.32
Autoproducer Electricity Plant	-99,333.00	-	-	-	-	-	-	-	19,443.60	-	-79,889.40
Public CHP Plant	-	-	-	-	-	-	-	-	-	-	-
Autoproducer CHP Plant	-	-	-	-	-	-	-	-29,632.00	1,080.00	-	-28,552.00
Public Heat Plant	-	-	-	-	-	-	-	-	-	-	-
Autoproducer Heat Plant	-	-	-	-	-	-	-	-	-	-	-
Heat pumps	-	-	-	-	-	-	-	-	-	-	-
Electric boilers	-	-	-	-	-	-	-	-	-	-	-
Gas Works	-134,520.18	-	-	29,965.33	-	-	-	-	-	-	-104,554.85
Oil Refineries	-	-985,431.56	985,431.56	-53.33	-	-	-	-	-48,322.40	-	-48,375.73
Coal Transformation	-20,546.25	-	-	-	-	-	-	-	-	-	-20,546.25
Liquefaction	-624,719.40	309,347.79	-	-71,814.00	-	-	-	-	-	-	-387,185.61
Non-specified (Transformation)	-	-	-	-	-	-	-	-	-	-	-
Own Use	-	-	-	-	-	-	-	-	-86,486.45	-	-86,486.45
											-
Distribution Losses	-	-	-	-	-	-	-	-	-55,058.99	-	-55,058.99
Total Final Consumption	**683,581.91**	**-**	**747,142.17**	**29,912.01**	**-**	**-**	**-**	**400,000.00**	**534,963.71**	**-**	**2,395,599.80**
Industry Sector	581,847.29	-	72,913.20	28,588.24	-	-	-	-	323,385.34	-	1,006,734.06
Iron and Steel	160,211.26	-	-	10,747.68	-	-	-	-	56,267.50	-	227,226.44
Chemical and Petrochemical	250,839.64	-	-	2,866.32	-	-	-	-	9,087.32	-	262,793.28
Memo: Feedst.Use In Petchem.Ind.	*205,875.00*	-	-	-	-	-	-	-	-	-	*205,875.00*
Non-Ferrous Metals	-	-	-	972.05	-	-	-	-	46,964.82	-	47,936.87
Non-Metallic Minerals	32,550.04	-	-	5,739.52	-	-	-	-	4,116.08	-	42,405.64
Transport Equipment	-	-	-	201.23	-	-	-	-	31.63	-	232.86
Machinery	-	-	-	4,733.78	-	-	-	-	413.79	-	5,147.57
Mining and Quarrying	14,973.61	-	18,677.42	325.00	-	-	-	-	125,393.03	-	159,369.06
Food and Tobacco	-	-	-	949.06	-	-	-	-	1,809.06	-	2,758.12
Paper Pulp and Print	-	-	-	387.97	-	-	-	-	3,487.49	-	3,875.46
Wood and Wood Products	-	-	-	271.23	-	-	-	-	2,125.57	-	2,396.80
Construction	-	-	13,595.09	-	-	-	-	-	56.10	-	13,651.19
Textile and Leather	-	-	-	101.30	-	-	-	-	1,767.47	-	1,868.77
Non-specified (Industry)	123,272.74	-	40,640.69	1,293.10	-	-	-	-	71,865.48	-	237,072.01
Transport Sector	631.85	-	548,270.08	13.91	-	-	-	-	15,387.62	-	564,303.46
International Civil Aviation	-	-	29,350.95	-	-	-	-	-	-	-	29,350.95
Domestic Air Transport	-	-	26,416.38	13.91	-	-	-	-	46.41	-	26,476.70
Road	-	-	484,311.35	-	-	-	-	-	27.14	-	484,338.49
Rail	631.85	-	7,481.89	-	-	-	-	-	12,406.30	-	20,520.04
Pipeline Transport	-	-	-	-	-	-	-	-	212.73	-	212.73
Internal Navigation	-	-	-	-	-	-	-	-	-	-	-
Non-specified (Transport)	-	-	709.51					-	2,695.04	-	3,404.55
Other Sectors	101,102.77	-	94,359.20	1,309.86	-	-	-	400,000.00	196,190.75	-	792,962.58
Agriculture	6,539.70	-	62,750.52	-	-	-	-	-	18,371.08	-	87,661.29
Commerce and Public Services	35,163.07	-	2,426.05	839.45	-	-	-	-	71,302.46	-	109,731.03
Residential	59,400.00	-	29,062.51	470.41	-	-	-	-	106,517.21	-	195,450.13
Non-specified (Other)	-	-	120.13	-	-	-	-	400,000.00	-	-	400,120.13
											-
Non-Energy Use	-	-	31,599.69	-	-	-	-	-	-	-	31,599.69
Memo:Non-Energy Use Ind/Transf/Ene	-	-	31,599.70	-	-	-	-	-	-	-	31,599.70
Memo:Non-Energy Use in Transport	-	-	-	-	-	-	-	-	-	-	-
Memo:Non-Energy Use in Oth. Sect	-	-	-	-	-	-	-	-	-	-	-
Elect.Output in GWh	184,952	-	-	-	11,775	1,319	-	300	-	-	198,346
Elect.Output-public elec. plant	179,551	-	-	-	11,775	1,319	-	-	-	-	192,645
Elect.Output-autoprod. elec. plant	5,401	-	-	-	-	-	-	-	-	-	5,401
Elect.Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-
Elect.Output-autoprod. CHP plant	-	-	-	-	-	-	-	300	-	-	300
								-			
Heat Output-public CHP plant	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoproducer CHP plant	-	-	-	-	-	-	-	-	-	-	-
Heat Output-public heat plant	-	-	-	-	-	-	-	-	-	-	-
Heat Output-autoprod. heat plant	-	-	-	-	-	-	-	-	-	-	-
Heat Output in TJ	-	-	-	-	-	-	-	-	-	-	-

DATA SOURCE: Institute for Energy Studies, RAU
BALANCE FORMAT: International Energy Agency, Paris

This Sheet Compiled on: 05-Aug-99
Last updated on: 28-Aug-98

The aggregated energy balance for South Africa for 1996 is shown in Table 6.10. Because different energy units can be used, the prototype system was written so as to provide the user with a selection of common units. These are TJ (which is the standard output unit), toe, tce (tonnes coal equivalent), Btu and GWh.

6.3.1.3 Flow diagram

A special snapshot output is the energy flow diagram. This diagram is a very useful way of depicting the flow of energy for a particular time period, usually a calendar year. All of the data essential for developing the flow diagram is encapsulated in the energy balance.

The production of regular national energy flow diagrams deserves serious consideration. The presentation of the energy economy as a flow diagram enhances the understanding of a country's energy economy to a degree beyond measure. Flow diagrams can be very simple, amounting to no more than a series of boxes representing activities on the path from primary energy through conversion activities to final use. The boxes are joined by arrows to indicate the flows as they are in the real world. The value of each flow added to each arrow indicates the size of the flow. These simple diagrams can sometimes be misunderstood if the user does not have a grasp of the magnitude of the numbers presented.

Producing a more complex drawing, with the arrows correctly to scale, makes the relative importance of different fuels and end-use sectors much more obvious. The various transformation processes, and their efficiencies, are also put into perspective. Different colours, or if unavailable, hatch patterns, for each energy carrier enhance the value of the diagram even further. Known flow diagrams produced for South Africa are for 1974 (Department of Planning and the Environment, 1977:85), 1991 (Cooper, 1993b) and 1993 (DME, 1996). To illustrate the principle, the flow diagrams for 1991 and 1993 are reproduced as Figures 6.1

and 6.2 respectively.

It could not be ascertained with certainty whether any proprietary software is available which will automatically produce flow diagrams. However, Allen (1999) indicated that the EIA uses the commercial package CorelDRAW, with the diagram drawn by hand and manually scaled. An EIA example for 1995 is reproduced as Figure 6.3 (EIA, 1996c:3) to show this output.

6.3.2 Time series analysis

While the energy balance and flow diagrams give a snapshot of energy flows for a specific time period, many analyses are dependent on a series of data over time. Such analyses typically track production, supply or consumption over time. Time series outputs where the changes in production or consumption of specific fuels are tracked are indispensable for some analyses. The deployment of time series outputs thus ranks with energy balances in importance.

Because different analysts require different specific outputs depending on the analysis being conducted, the system needs to be sufficiently flexible to meet these different needs. There are many permutations of fuels, sectors and geographical entities possible, and rigid outputs will entail the hard coding of many individual reports. This is very time consuming and costly so a flexible approach is suggested. In the approach developed here a measure of flexibility is attained by specifying a number of templates where the sectors in each report are hard-coded, while fuels and geographical entities can be selected by the analyst. A number of time series templates were developed which provide a comprehensive set of time series outputs.

There are no international standards for time series outputs, and the templates developed here have been done for SA. They are based on the elements encapsulated in the energy balance and on the practical requirements developed

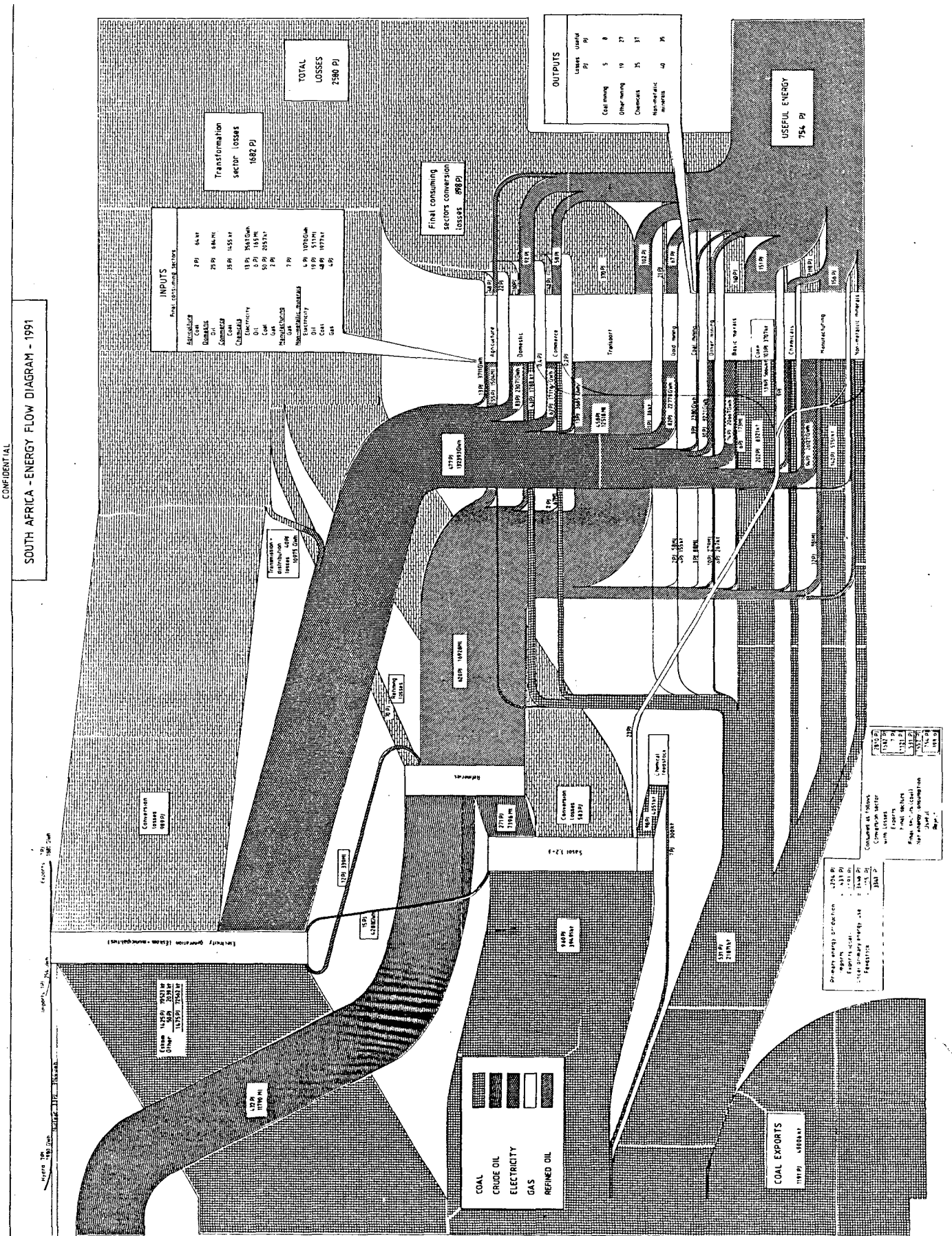


Figure 6.1: South African energy flow diagram – 1991 (Cooper, 1993b)

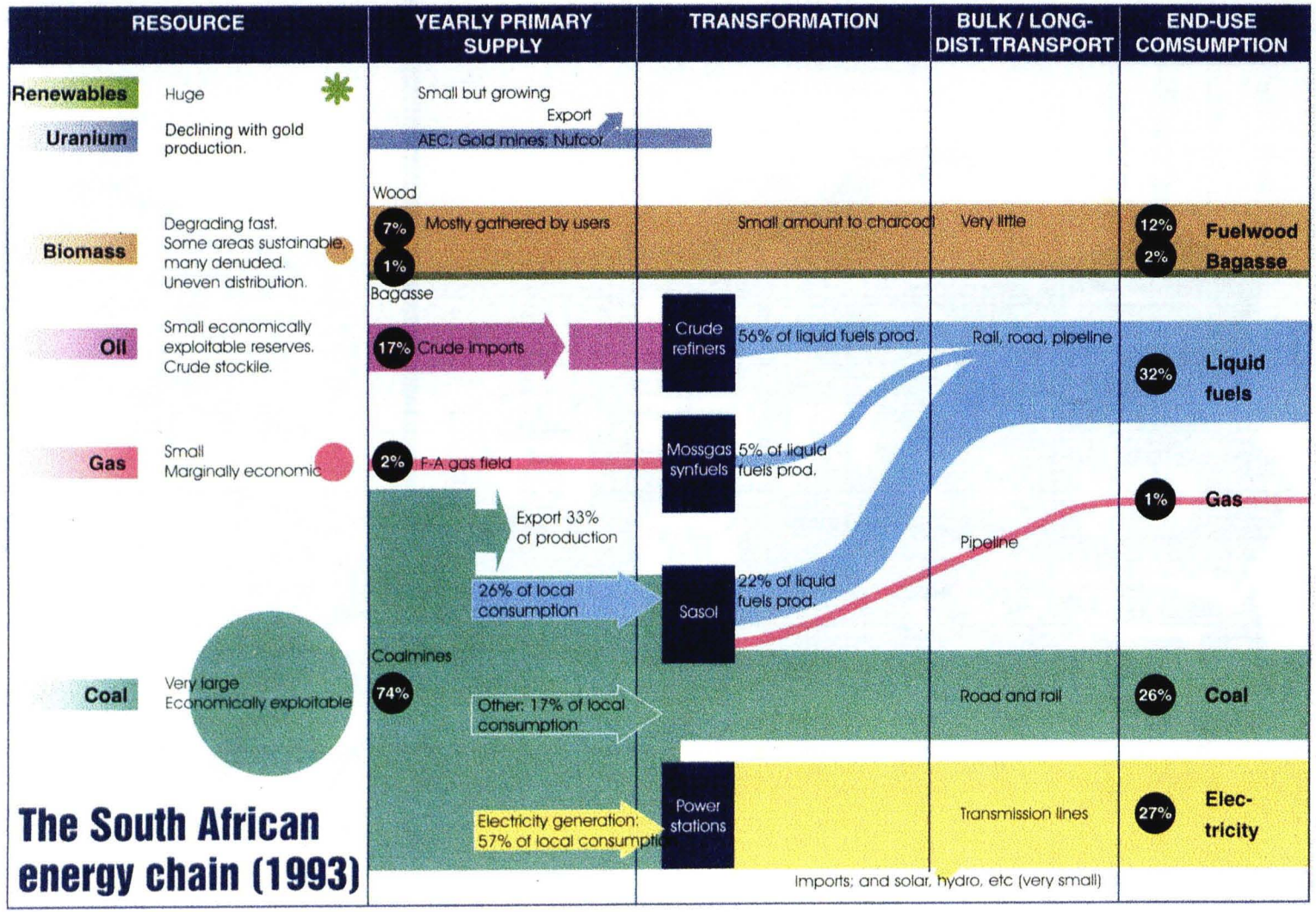


Figure 6.2: South African energy flow diagram – 1993 (DME, 1996)

Diagram 1. Energy Flow, 1995
(Quadrillion Btu)

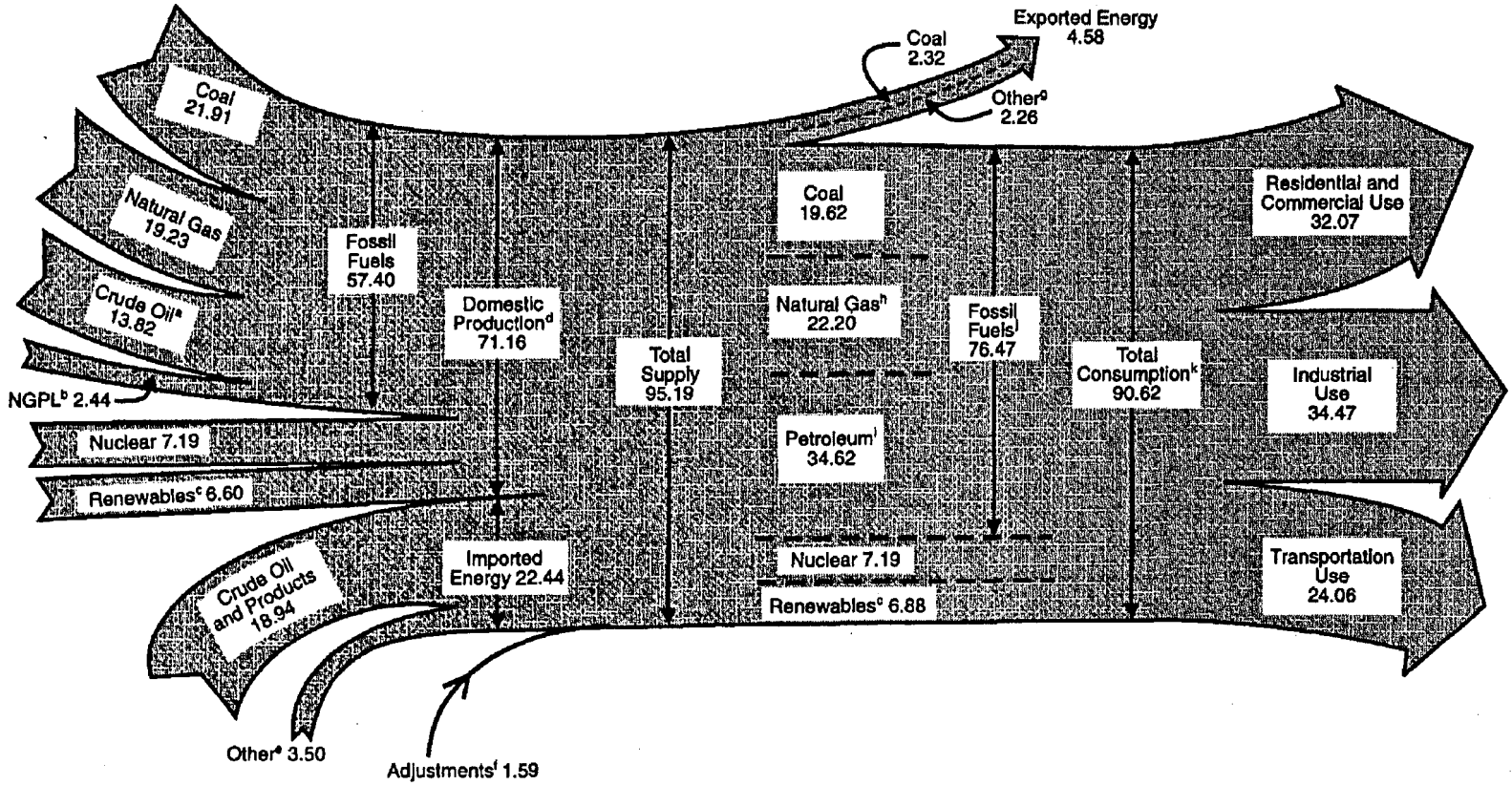


Figure 6.3: US Energy Flow Diagram – 1995 (EIA, 1996c:3)

by the author over more than a decade of energy analysis. For simplicity and to reduce programming requirements, the use of units of original measurement is recommended. This does not preclude later development of modules to produce these reports in a common energy unit. By specifying outputs in a commercial spreadsheet format, the user is provided with the flexibility to further customise outputs by merging outputs for different fuels using commercial software packages.

The time series tables have been divided into two logical types. The first is for individual fuels and the second for fuel groups. The individual templates as developed for the prototype system, together with an explanation of the options, is given in the following sub-sections of this thesis.

Because of the large amount of information available, especially when elements for different years and spatial dimensions are considered, it is prudent to extract information for individual fuels for ease of analysis. The large number of sectors also suggests that a series of tables would make analysis easier.

It is proposed that the sectoral analysis be allocated into the natural divisions as encapsulated in the basic table and energy balance. Thus the following time series tables are proposed:

- Primary supply.
- Transformation sector.
- Energy sector.
- Industrial sector.
- Transport sector.
- Other sectors.
- Non-energy purposes.
- Summary of final demand.

6.3.2.1 Primary supply

This table indicates the indigenous production, imports, exports, stock changes, marine bunkers, and therefor shows energy available for consumption. The system must make provision for selection of fuel and spatial dimension, although in practice this will probably be for the country rather than on a provincial basis. The layout for the table is given in Table 6.11 with data extracted from the prototype system for bituminous coal for South Africa. One output which is not shown here, but which needs to be developed, would show country of destination for exports and country of origin for imports of any fuel in the database.

6.3.2.2 Transformation sector

The transformation sector is the next logical division. In this output the amount of energy transformed to other fuels (and thus available as consumption energy) is tracked. The number of fuels for which data can be extracted is obviously limited to those that are transformed. The output template is presented in Table 6.12, again using bituminous coal as sample fuel as contained in the prototype system.

6.3.2.3 Energy sector

The energy sector is the economic sector responsible for transforming energy. This is the first consuming sector, and the energy measured is not the transformed energy (see 6.3.2.2), but the process energy. Process energy is the energy used by specific processes to produce secondary fuels for other sectors. Thus a refinery transforms crude oil into finished petroleum products, and in the transformation process uses electricity and some product as fuel i.e. process energy. Table 6.13 shows the output template using electricity as the sample fuel.

Table 6.11: Sample of primary supply time series outputs

SOUTH AFRICA
PRIMARY SUPPLY OF BITUMINOUS COAL GENERAL
t

Year	Indigenous Production	From Other Sources	Imports	Exports	International Bunkers	Stock Changes	Gross Consumption (Domestic Supply)
1990	171,378,196			-49,566,420		8,494,025	130,305,801
1991	174,307,363			-49,477,092		5,037,423	129,867,694
1992	169,557,236			-49,637,675		7,166,863	127,086,424
1993	177,571,380			-52,189,311		3,561,528	128,943,597
1994	191,608,568			-54,838,320		-5,296,497	131,473,751
1995	202,350,878			-59,676,058		309,726	142,984,546
1996	202,829,479			-60,224,402		2,836,869	145,441,946
1997	216,425,514			-64,200,000		-2,445,452	149,780,062

Last updated on: 28-Aug-1998

Table 6.12: Sample of energy transformation sector time series outputs

SOUTH AFRICA
ENERGY TRANSFORMATION SECTOR
BITUMINOUS COAL GENERAL
t

Year	Public Electricity Plant	Autoproducer Electricity Plant	Public CHP Plant	Autoproducer CHP Plant	Public Heat Plant	Autoproducer Heat Plant	Heat Pumps	Electric Boilers	Patent Fuel Plants	Coke Ovens	Gas Works	For Blast Furnace Gas	Petrochemical Industry	For BKB	Oil Refineries	Liquefaction	Non Specified	Total
1980	70,661,200	3,326,000									4,102,662					28,267,000		106,556,862
1981	72,581,898	3,393,000									4,002,840					27,057,000		107,014,738
1982	72,920,197	3,917,000									6,111,551					24,457,000		107,405,748
1983	77,315,235	3,407,000									4,433,498					25,317,000		110,472,733
1984	79,132,026	3,424,000									4,489,480					25,506,000		112,645,506
1985	82,603,226	3,833,000									4,868,292					28,051,000		119,355,518
1986	87,213,899	3,679,000									4,982,229					28,526,000		124,401,128
1987	91,670,100	3,781,000									5,363,428					27,766,000		128,780,528

Last updated on: 28-Aug-1998

Table 6.13: Sample of energy sector time series outputs

SOUTH AFRICA
CONSUMPTION OF ELECTRICITY BY THE ENERGY SECTOR
MWh

Year	Coal Mines	Oil & Gas Extraction	Patent Fuel Plants	Coke Ovens	Gas Works	BKB	Oil Refineries	Own Use in Elec. CHP and Heat Plant	Used for Pump Storage	Nuclear Industry	Non Specified	Total
1990	2,322,897						10,132,032	10,917,000	2,522,000			25,893,929
1991	2,336,402						10,387,419	11,243,520	2,471,480			26,438,820
1992	2,348,925						11,206,419	10,709,790	1,826,210			26,091,344
1993	2,413,806						12,653,224	10,175,350	1,842,650			27,085,029
1994	2,525,844						12,630,378	9,821,710	2,078,290			27,056,222
1995	2,565,552						13,232,168	12,193,620	1,745,380			29,736,720
1996	2,732,376						13,422,889	12,562,600	3,041,400			31,759,265
1997	2,848,394						12,908,192	12,691,040	3,572,960			32,020,586

Last updated on: 28-Aug-1998

6.3.2.4 Industrial sector

The industrial sector is the first of the final consuming sectors, and the largest in terms of the number of sub-sectors. The system must make provision for the selection of any fuel and any spatial dimension. The output template is shown in Table 6.14 using electricity as sample fuel, and the whole of South Africa as spatial dimension. It is possible to select a specific province for this output.

6.3.2.5 Transport sector

The transport sector time series template indicates the use of energy by various transport modes. Table 6.15 shows the use of all petroleum fuels by the sector for South Africa. As for the industrial sector, outputs can be extracted for any of the provinces and also for other specific fuels such as petrol or diesel.

6.3.2.6 Other sectors

This grouping is for sectors that are neither industrial nor transport and includes any consumption that cannot be allocated to any other sector. The agricultural, commercial buildings and public services and residential sectors are included in this grouping. Table 6.16 provides a template showing electricity consumption by these sectors. This information can also be extracted for specified spatial dimensions.

6.3.2.7 Non-energy purposes

Some energy carriers are used for non-energy purposes. The best examples are coal and oil when used as a chemical feedstock. Table 6.17 shows the analysis for bituminous coal used for non-energy purposes for South Africa. The output can also be done for specific provinces.

Table 6.14: Sample of industrial sector time series outputs

SOUTH AFRICA
FINAL CONSUMPTION OF ELECTRICITY BY THE INDUSTRIAL SECTOR
MWh

Year	Iron & Steel	Chemicals	Non-Ferrous Metals	Non-Metallic Minerals	Transport Equipment	Machinery	Mining & Quarrying	Food, Beverages and Tobacco	Pulp, Paper and Printing	Wood and Wood Products	Construction	Textiles and Leather	Industry not Specified	Total
1990	14,662,393	3,166,264	5,509,071	1,194,060	2,548	119,058	35,166,479	355,320	753,612	572,461	21,554	365,579	27,029,823	88,918,222
1991	14,274,984	2,952,191	5,961,531	1,093,520	3,324	95,023	34,139,327	363,644	794,423	551,141	31,127	365,150	26,678,992	87,304,378
1992	11,401,626	3,179,219	6,146,974	985,506	4,206	95,302	33,961,616	374,663	939,117	491,269	19,540	372,161	18,112,563	76,083,762
1993	12,606,239	3,017,031	6,234,421	962,887	4,224	108,733	32,025,978	369,112	870,404	485,755	11,122	388,949	24,036,868	81,121,723
1994	14,604,236	3,149,618	5,945,376	1,051,387	6,059	99,640	32,668,096	411,335	843,117	505,110	14,615	413,975	19,276,701	78,989,265
1995	16,250,811	3,065,592	6,956,009	1,190,263	8,590	104,087	32,474,397	454,207	975,054	534,173	13,805	475,421	19,726,115	82,228,523
1996	15,629,860	2,524,255	13,045,785	1,143,355	8,785	114,943	34,831,399	502,518	968,747	590,434	15,582	490,963	19,962,636	89,829,262
1997	17,874,693	2,432,475	14,583,625	1,187,804	10,553	127,224	30,390,344	539,287	1,029,378	596,025	16,774	513,511	22,158,329	91,460,022

Last updated on: 28-Aug-1998

Table 6.15: Sample of transport sector time series outputs

SOUTH AFRICA
FINAL CONSUMPTION OF PETROLEUM BY THE TRANSPORT SECTOR
kl

Year	International Civil Aviation	Domestic Air Transport	Road Transport	Rail	Pipeline	Inland Waterways	Transport not Specified	Total
1990		885,709	11,315,543	382,597			14,717	12,598,566
1991		887,107	11,544,954	326,015			13,290	12,771,366
1992		1,036,081	11,729,270	302,329			4,356	13,072,036
1993		1,124,451	11,828,364	258,702			6,423	13,217,940
1994		1,218,926	12,354,442	261,683			49,135	13,884,186
1995	697,987	696,498	13,127,032	250,762			15,720	14,787,999
1996	855,713	770,450	13,783,084	196,375			19,548	15,625,170
1997	981,006	823,875	13,614,376	196,785			535,692	16,151,734
							Last Updated on:	28-Aug-1998

Table 6.16: Sample of other sectors time series outputs

SOUTH AFRICA FINAL CONSUMPTION OF ELECTRICITY BY OTHER SECTORS MWh					
Year	Agriculture	Residential	Commerce and Public Service	Other not Specified	Total
1990	5,166,979	19,822,371	12,873,898		37,863,248
1991	5,271,627	19,346,783	13,247,500		37,865,910
1992	4,038,000	24,253,405	17,483,826		45,775,231
1993	3,108,101	26,957,008	19,001,389		49,066,498
1994	4,879,762	27,483,484	19,426,892		51,790,138
1995	5,096,348	28,787,762	20,031,424		53,915,533
1996	5,103,080	29,588,114	19,806,240		54,497,433
1997	5,639,987	30,722,498	22,169,809		58,532,293
				Last updated on:	28-Aug-1998

Table 6.17: Sample of non-energy use time series outputs

SOUTH AFRICA
FINAL CONSUMPTION OF BITUMINOUS COAL GENERAL FOR NON-ENERGY PURPOSES
t

Year	Industry, Transformation and Energy Sectors	Transport Sector	Other Sectors	For Chemical Feedstocks	Total
1990				4,117,000	4,117,000
1991				4,762,000	4,762,000
1992				4,148,000	4,148,000
1993				5,165,000	5,165,000
1994				5,203,000	5,203,000
1995				7,349,000	7,349,000
1996				7,625,000	7,625,000
1997				7,617,000	7,617,000

Last updated on: 28-Aug-1998

6.3.2.8 Summary of final demand

It is useful to see, on a single table, the main sectoral allocation for a particular fuel. This output is designed to provide the user with this information. Table 6.18 gives a sample of this output for electricity.

6.3.2.9 Summary of electricity production

There are a number of different fuels that can be used for electricity generation. This output table (Table 6.19) provides a summary of the primary inputs to electricity generation and can only be extracted for the country as a whole.

6.3.3 Outputs for fuel groups

Outputs presented in the previous section were, in general, limited to individual fuels. There is a need for outputs where summary information for fuel groupings is presented. The outputs discussed in this section are designed to meet this need.

6.3.3.1 Liquid fuels

A table providing the analyst with the volumes of the main liquid fuels consumed is considered essential for any analysis of the liquid fuel mix. Table 6.20 shows the template for this output.

6.3.3.2 Biomass

The IEA has divided biomass into a number of fuels, and a single tabulated output will show the relative importance of each fuel in the economy being analysed. Table 6.21 provides the template for this output. No data was captured, hence the appearance of the output table. The output can be specified for a selected province or for the entire country.

Table 6.18: Sample of sectoral time series summary outputs

SOUTH AFRICA

CONSUMPTION OF ELECTRICITY

MWh

					Final Consumption				
Year	Domestic Supply	Transformation Sector	Energy Sector	Distribution Losses	Total	Industry	Transport	Other Sectors	Non-Energy Purposes
1990	160,681,000		25,893,929	11,128,080	131,333,172	88,918,222	4,551,702	37,863,248	
1991	162,634,000		26,438,820	11,193,824	129,436,287	87,304,378	4,265,999	37,865,910	
1992	166,335,200		26,091,344	12,032,791	126,488,051	76,083,762	4,629,058	45,775,231	
1993	172,091,600		27,085,029	12,758,818	134,204,922	81,121,723	4,016,701	49,066,498	
1994	179,827,000		27,056,222	14,031,000	135,168,301	78,989,265	4,388,898	51,790,138	
1995	185,240,000		29,736,720	14,318,327	140,394,058	82,228,523	4,250,001	53,915,533	
1996	*194,542,000*		*31,759,265*	*15,294,163*	*148,601,028*	*89,829,262*	4,274,334	54,497,433	
1997	203,740,000		32,020,586	16,093,796	154,554,837	91,460,022	4,562,522	58,532,293	

Last updated on: 28-Aug-1998

Table 6.19: Sample of electricity production time series outputs

SOUTH AFRICA
PRODUCTION OF ELECTRICITY
GWh

			From Thermal Sources			
Year	Nuclear	Hydro & Pumped Storage	Coal	Renewables	Petroleum	Total Electricity
1990	8,449	2,851	4,156			15,456
1991	9,144	3,784	4,183			17,111
1992	9,288	2,085	156,143			167,516
1993	7,255	1,491	165,535			174,281
1994	9,697	2,591	169,540			181,828
1995	11,301	1,803	174,721	266		188,091
1996	11,775	3,539	184,952	300		200,566
1997	12,647	4,700	192,705	300		210,352

Last updated on: 28-Aug-1998

Table 6.20: Sample of petroleum product consumption time series summary outputs

SOUTH AFRICA
CONSUMPTION OF PETROLEUM PRODUCTS
kl

Year	LPG	Mogas		Avgas	Jet Fuel (Jet A-1)	Kerosene		Diesel	HFO
		Leaded Mogas	Unleaded Mogas			Illuminating Paraffin	Power Paraffin		
1990	315,598	8,633,321		24,910	860,799	723,688	31,638	5,453,639	585,802
1991	380,527	8,906,661		23,113	863,993	725,944	25,994	5,268,084	494,873
1992	461,976	9,170,436		27,264	1,008,817	742,865	22,041	4,985,184	560,109
1993	475,107	9,202,067		24,825	1,099,626	833,633	20,460	4,976,806	591,845
1994	484,547	9,629,568		26,393	1,192,533	874,803	20,054	5,159,197	555,326
1995	492,393	10,153,587		26,076	1,368,410	853,294	17,671	5,482,695	506,289
1996	472,645	9,693,503	873,252	25,157	1,601,006	916,996	15,024	5,809,638	719,725
1997	527,374	9,762,694	950,104	28,496	1,776,386	971,735	11,204	5,912,661	634,300

Last updated on: 28-Aug-1998

Table 6.21: Sample template for biomass consumption time series outputs

#REF! CONSUMPTION OF BIOMASS FUELS #REF!					
Year	Wood	Charcoal	Vegetal Waste	Black Liquor	Other Solid Biomass
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
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#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
				Last updated on:	#REF!

Table 6.22: Sample template for waste time series outputs

#REF! CONSUMPTION OF ENERGY FROM WASTE #REF!						
			Gases from Biomass			
Year	Industrial Waste	Municipal Solid Waste	Total	Landfill Biogas	Sludge Gas	Other Biogas
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
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					Last updated on:	#REF!

6.3.3.3 Energy from waste

It is becoming common in many countries for waste to be used as an energy source. In most instances the waste is incinerated to produce steam. The steam is used further to generate electricity, or to produce heat for district heating, or as industrial process heat. Some wastes produce gas that can be used as an energy source. For example gas can be produced from landfill sites, as has been shown in experiments conducted in SA in Grahamstown and Johannesburg. Table 6.22 gives the template for energy from waste. While this template was coded into the prototype system, no data was available for inclusion in the database. The output can be for a specified province or for the entire country.

6.3.3.4 Summary of main fuels

A summary table presenting the use of the main fuels at final demand level provides an overview of energy consumption for the specified sector. Table 6.23 presents a view of the output. This output was not included in the coding for the prototype system. It is envisaged that the user will be able to select spatial dimensions and units. For units, the choice will be between conventional energy units or a common energy unit of measurement.

Table 6.23: Sample template for sectoral energy consumption time series outputs

CONSUMPTION OF ENERGY BY THE {SELECT SECTOR} FOR {SPATIAL DIMENSION} IN {UNITS}				
Year	Solid Fuels	Petroleum Products	Gas	Electricity

6.3.4 End-use outputs

End-use refers to the final use of a fuel. In general end-use can be classified as thermal, mechanical, transport, light, chemical (usually electro-chemical), electronic, and feedstock (non-energy). Transport is an end-use that can be classified as mechanical or possibly thermal (e.g. jet fuel), but a separate classification is appropriate for detailed analysis. Detailed end-use outputs were developed by the researcher and provide one format which can be used (Cooper, 1994a).

There are processes using specified equipment types where individual installations can be identified. Examples include boilers, furnaces, air conditioning equipment and kilns. If information on location and ownership of individual equipment can be obtained then surveys can be conducted to determine and locate specific fuel consumption. The sections that follow provide some details of potential surveys.

6.3.4.1 Boiler data

One specific data table which can be categorised as an end-use, for which information can be relatively easily collected, is boiler details. All boilers must be registered with the Department of Labour and this database can be captured into the proposed system. By requesting specific data concerning each boiler in the country, a detailed data table can be compiled for boilers. In boilers a fuel is used to provide heat, which boils water to produce steam, which is further used to produce electricity, or to provide motive power, or process heat. Each boiler has characteristics that can be coded and captured into the information system. Because this is a specific topic that has been identified, it should be developed further. An informal start has been made by the researcher to develop the data tables required and to collect the necessary infrastructure and energy data.

Each boiler is operated by an institution that can be classified by sector and location. It burns a known fuel in known quantities, and has measurable characteristics (such as capacity), is of a known design, and was built by a known manufacturer. The commissioning date should be known, as should any ancillary equipment such as environmental controls. A survey of all boilers is feasible and should provide, with relative ease, a comprehensive data set. The system must enable the user to access this data so as to provide answers to, amongst others, questions about fuels used, locations and an estimate of emissions. By linking the location to a GIS system, areas of, for example, high CO_2 emissions can be identified.

6.3.4.2 Other specific energy consuming equipment

It is feasible to identify other types of energy consuming equipment for which data is desired. Examples include kilns, ovens and furnaces. There may be compelling reasons for identifying and surveying such equipment for monitoring energy use, physical outputs and environmental emissions and controls. A data structure similar to that for boilers would be required. It will probably be advantageous to combine this data for equipment with that for boilers, thus simplifying the system.

6.4 ECONOMIC AND DEMOGRAPHIC OUTPUTS

The relationship between energy consumption and economic output is of fundamental importance to energy analysts and for policy formulation. The relationship (and its changes over time) is used as the basis for modelling efforts to determine, amongst others, likely future demand for particular fuels. For a capital intensive industry with lengthy construction lead times, these models and their outputs are of great importance when planning for future investment in supply capacity. The relationship is also used to determine the efficiency with which different factories, industries or countries are utilising energy. Many

research projects, journal articles, conference papers and books have been completed on this complex topic.

The integrated energy information system needs to be designed with the extraction of energy/economic relationships in mind. The implication is that economic data must also be collected, and in a form compatible with and comparable to the energy data. This will provide a means for calculating energy/economic ratios.

Economic data, in the context used in this study, is not limited to traditional economic measures such as Gross Domestic Product (GDP) or other financial data, but also extends to physical output and/or other parameters of measurement. It is, for example, insufficient to know only the monetary value of cement production - the physical volume of cement production is also needed.

Initial implementation can be done at two levels. The first would be at a macro level, using macro-economic indicators such as GDP, PCE or GGP and is discussed here. The second or micro level, using process data is discussed in 6.5.

It needs to be noted that inter-country comparisons at the macro level, especially using GDP, must be made with great care. It is easy to misinterpret different (or even, for that matter, similar) values when comparative analyses are made. An example is that of South Africa's energy/economic relationship or energy intensity (total primary energy supply compared to GDP). The value is high by world standards, but it must be remembered that the SA economy is characterised by large, very energy intensive mining, base metal and chemical industries. These use a high percentage of energy for proportionally much lower percentage of economic output (measured as contribution to GDP). Countries where service type contribution to GDP is much higher will show a lower energy intensity.

Energy/economic outputs are also dynamic - the calculated values of the outputs are used by other system modules for additional calculations. For example, the calculated values can be used in an econometric modelling module to produce projections of possible future energy consumption patterns.

The Kyoto protocol requires countries to measure and improve on efficiencies of energy utilisation in order to reduce greenhouse gas emissions. The environmental outputs are discussed in section 6.7. There is a concern for countries to improve energy utilisation efficiencies in order to meet Kyoto goals, while providing an increased standard of living for citizens.

6.5 EFFICIENCY OUTPUTS

Energy efficiency is very closely related to energy intensities, and here the micro level of analysis needs to be made at process level. Here the energy input to a specific process is related to the physical output from the process. To return to the cement industry example, a measure of the amount of energy required to produce a single ton of cement needs to be known. With this information a true comparison of energy intensities between countries for cement production can be made.

The outputs need to be at different levels of detail and the system will need to accommodate multiple levels of disaggregation. In addition to snapshot data, time series information is also required. Time series outputs are required to track changes in efficiency over time.

6.6 PRICE OUTPUTS

The price of different fuels can, and does, affect consumption patterns. Government can use taxes or subsidies to modify consumption patterns to meet policy objectives. Energy pricing is an important aspect of energy policy

formulation and implementation. Most countries track energy prices and many publish details. The IEA collects much of this data from member countries and compiles a quarterly report on prices and taxes (IEA, 1997d). Such comparisons can be used to provide some measure of a country's competitiveness when energy inputs are costed.

From a consumer point of view, information on the comparative prices for different fuels is important to determine the most cost effective fuel for specific processes or purposes.

A price output is thus another important output required from an integrated system. Prices to end users and tax components should be included. Actual end user prices are difficult to obtain as these are often of strategic importance and are kept confidential by provider and consumer. Prices which can be collected, and which form a useful base for further analysis, are list prices.

As part of the national energy database project (Cooper, 1998c), a report on energy prices was developed. Selected outputs are included as Appendix C.

6.7 ENVIRONMENTAL OUTPUTS

It has been noted that outputs can be linked to a GIS. Such links are ideal for analysing the spatial distribution of environmental 'hot spots'. Providing that energy consumption data is collected at a high level of spatial disaggregation, graphic representation of emissions could be very useful in identifying the location of environmental loadings. These emissions would be calculated for the amount of fuel used and the chemical constituents of that fuel. Ash, sulphur and carbon dioxide are examples of emissions or wastes that can be determined. Information on installed environmental control equipment can also be maintained.

6.8 PROJECT OUTPUTS

As defined in Chapter 3, a register of both potential and current projects is required. The outputs will include a mix of statistical and textual data. If the location of the project is available in co-ordinate form, the location can be included in a GIS output.

A sample template for project outputs is given in Figure 6.4 below.

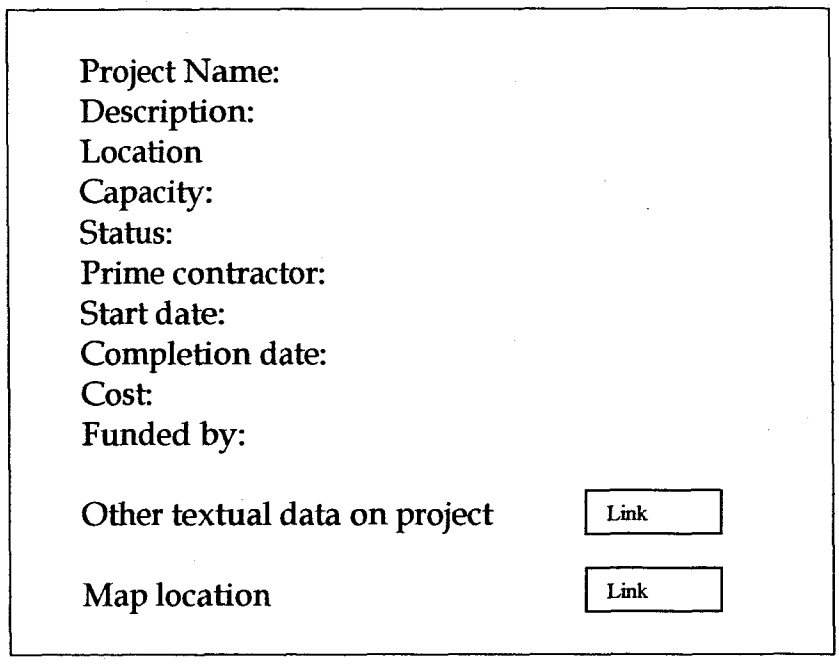

Figure 6.4: Sample output for project data

6.9 INFRASTRUCTURE OUTPUTS

Outputs for infrastructure must provide the user with details of the major energy infrastructure of the country. The output template must include the items shown in the sample given in Figure 6.5:

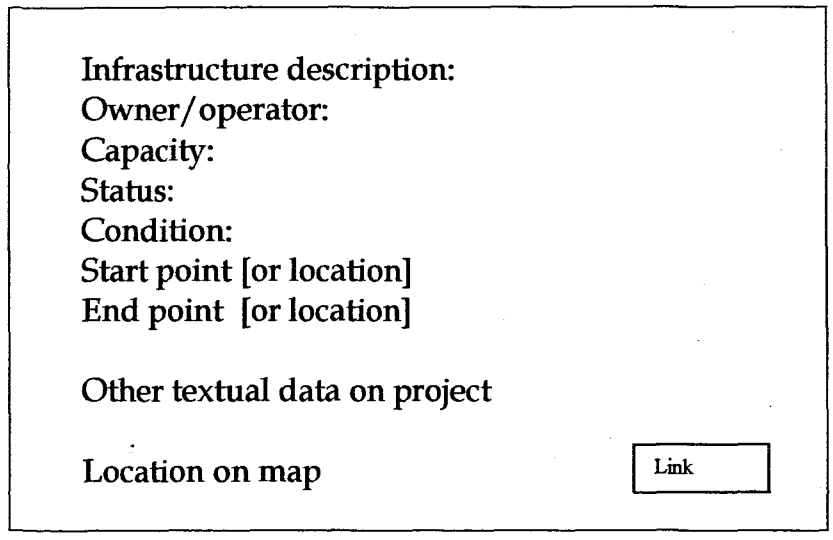

Figure 6.5: Sample of outputs for infrastructure data

The link to map location can be used to present the information graphically through a GIS. An example to illustrate how such outputs could look is given in Figure 6.6. This is for the liquid fuels pipeline network between KwaZulu and Gauteng and is taken from a recent IEA study on South African Energy Policies (IEA 1996:20).

6.10 CONTACTS OUTPUTS

The outputs from the contacts module provide the user with details of companies, institutions and people associated with the energy industry, and should include the following:

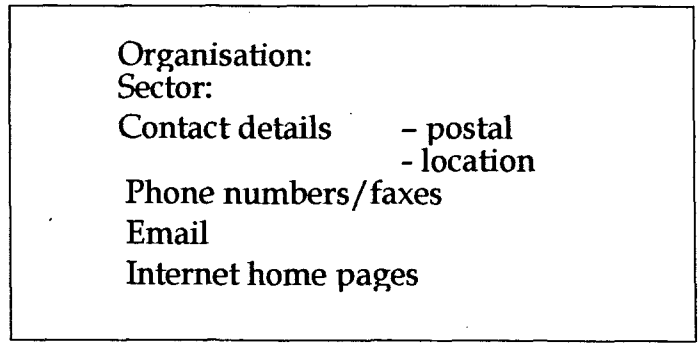

Figure 6.7: Sample of contacts outputs

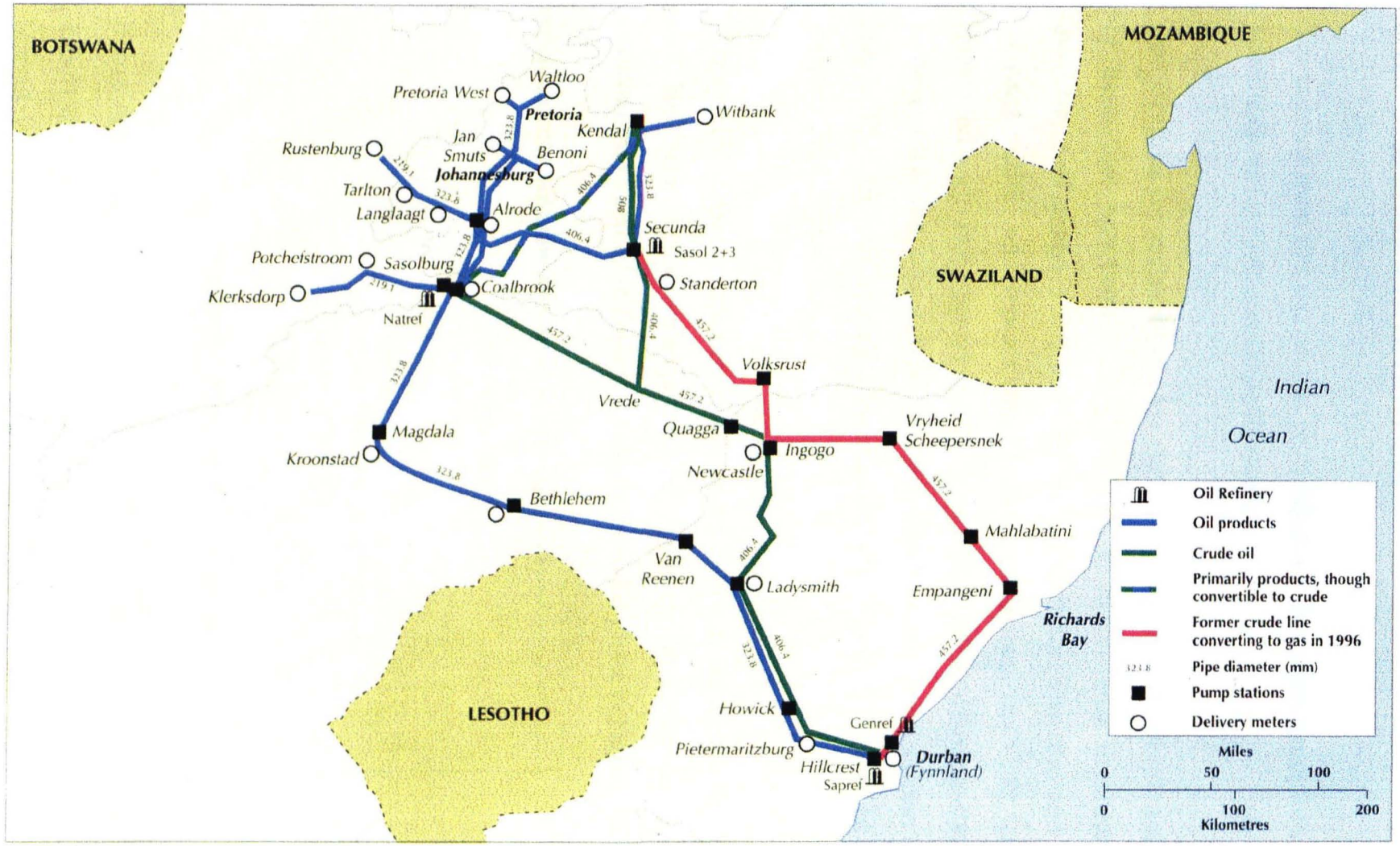

Figure 6.6: Sample GIS type output showing infrastructure (IEA 1996:20)

6.11 SPECIFICATION OUTPUTS

The outputs from this section can be divided into two main groupings. These are specifications for fuels and for equipment.

Specifications for fuels will include chemical analyses and calorific values. Some of these fuel specifications are available from different organisations. For example, coal analyses are done by the Council for Scientific and Industrial Research (CSIR) and reports from 1948 are available. The CSIR has recently developed a CD-ROM containing this data (CSIR, 1999), although distribution is limited as it is still in prototype form for evaluation purposes. Access to the data can be built into the energy system, although outputs will then be limited to those on the CD program.

The specifications for equipment are varied, and a fixed format for the outputs will not meet all the requirements. At the least, capacities and specific fuel consumption must be included. A sample format is given in Figure 6.8.

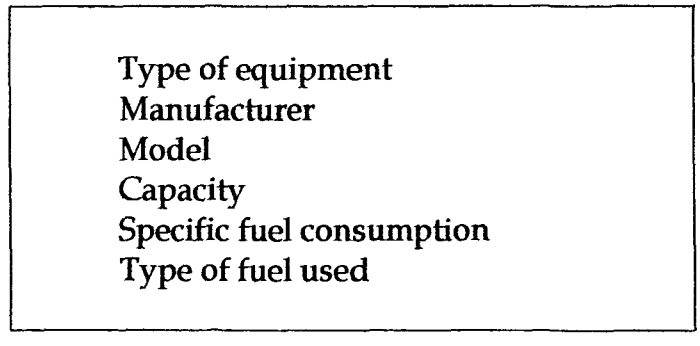

Figure 6.8: Sample of equipment outputs

It was noted that government would like to implement an equipment labeling requirement for domestic appliances. An appliance labeling example (Wilson & Morrill, 1996:247) from the USA is given in Figure 6.9.

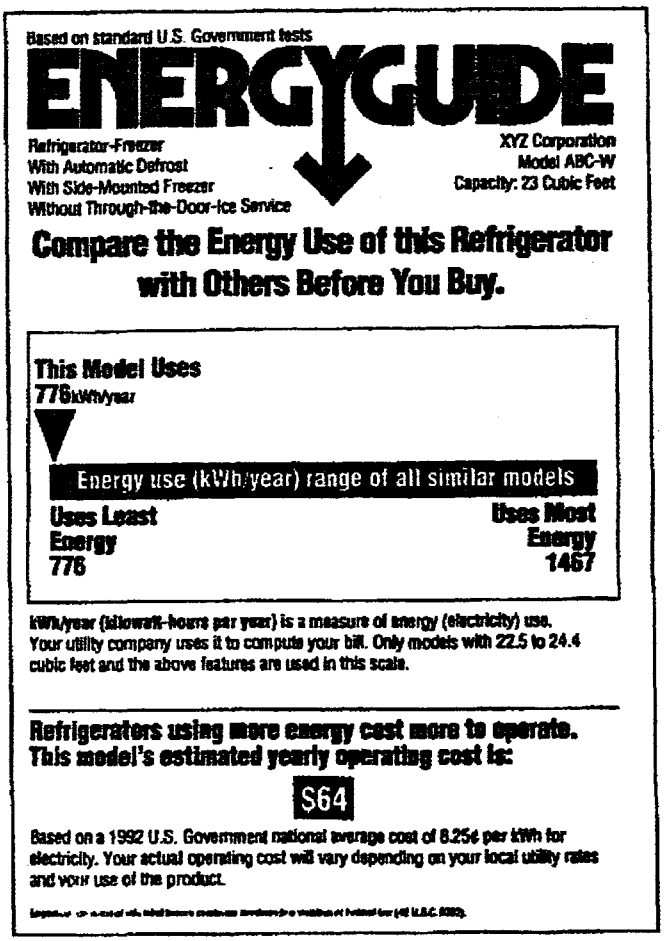

Figure 6.9: Sample of US appliance label (Wilson & Morrill, 1996:247)

6.12 BIBLIOGRAPHIC OUTPUTS

The module containing bibliographic data was considered necessary to provide users with information on reports and other reference material that would be of use for analyses. Three levels of output are included.

The first is the basic reference linked to topics, or keywords. Details must include author, title, publisher and date published. All bibliographic references must be classified into the system from a list of permitted keywords - similar to a glossary. A search, using keyword/s from this list, defines the topics of interest to the user, and the output would be similar to the bibliography of this thesis.

The second level allows the user to request an abstract of the material. This provides the user with more details of the content of a specific report or document listed in the basic bibliographic output. Unfortunately, not all textual documents captured will contain an abstract, and producing abstracts is a time consuming and expensive process. If the full text version of a document can not be made available, information on where it is available can be given.

The final level is to make a complete electronic copy of the text available to the user. Obviously copyrighted material cannot be freely accessible. There are, however, many reports and other publications emanating from the government and research organisations that can be included in the database. The EIA (1998) CD-ROM, which includes electronic copies of many of their reports and publications, is a very good example of this level of bibliographic output.

6.13 CASE STUDY OUTPUTS

Case studies include information on a particular installation or project. They give an overview of the problem; an evaluation of the situation prior to installation of new equipment; a description the equipment that is installed; and finally, operational results once the installation is complete and has been commissioned. While there may be statistical data included in a case study, the main form of data will be textual, i.e. the case study would be presented as a written report. In the UK, the organisation known as ETSU was formed to assist with improving energy efficiencies in the industrial sector. ETSU produced, and still produces, information on retrofit or new improved energy efficient equipment. Abstracts on their various publications have been published via the Internet, where they can be accessed and viewed (ETSU, 1999).

For the proposed energy information system, a basic bibliographic reference with a keyword search is recommended to select projects for which case study reports are available. The user will then be provided with a short abstract on the

particular study if this is available, or information on where to find hard copy. Access to an electronic copy of the full report can also be made available, where possible.

6.14 INTERNATIONAL OUTPUTS

International outputs relate to information of an international nature, rather than the narrower national perspective. The outputs are most likely to result from electronic interaction with existing data systems in other countries. Examples are the EIA and IEA databases that are available through the Internet.

Energy, economic and infrastructure data for the Southern African Development Community (SADC) is international data of particular interest to SA. In this regard, a restricted energy information system has been designed at conceptual level for the SADC Technical Assistance Unit (SADC-TAU) located in Luanda, Angola. The conceptual design for this system was done by the researcher (Cooper, 1999c). A design specification, which includes system management and output functions, has been developed from this concept by a company specialising in systems analysis, development and implementation (DYSIS, 1999). It should be possible to link to this system via the Internet once it becomes operational.

6.15 PRODUCT AND EQUIPMENT OUTPUTS

The data module on products was considered essential to ensure that details of energy-related products and equipment are contained in the system. There will be overlap with outputs from the specifications and contacts areas. Outputs will be obtained largely by searching for specified products or equipment. Details of manufacturers, agents or distributors for different products and equipment will be provided. The outputs can also be designed to provide operational details, and can be linked to case studies where appropriate. Tables containing comparative

data could be extracted to assist buyers in making educated decisions when replacing equipment (Wilson & Morrill, 1986:175-180). A sample from this listing is presented in Figure 6.10. A facility to link to contact details is also feasible and would be useful to system users.

MOST EFFICIENT REFRIGERATORS (Cont.)

Brand	Model	Volume	Energy use (kWh/yr)	Annual energy cost ($)
Top freezer, automatic defrost, 14.0 - 15.4 cubic feet				
Roper	RT14HK*A*0*	14.4	498	43
Roper	RT14HD*D*0*	14.4	498	43
Whirlpool	ET14NK*D*0*	14.4	498	43
Whirlpool	ET14UK*A*0*	14.4	498	43
Whirlpool	ET14GK*B*0*	14.4	498	43
Estate	TT14*K*A*0*	14.4	526	46
Roper	RT14DM*D*0*	14.4	526	46
Whirlpool	ET14J**A*0*	14.4	526	46
Top freezer, automatic defrost, 15.5 - 17.4 cubic feet				
General Electric	TBH16JAX	15.5	514	45
Hotpoint	CTH16CY*	15.6	514	45
RCA	MTH16CY*	15.6	514	45
Roper	RTR16VK*B*0*	16.4	557	48
Roper	RTR16DK*D*0*	16.4	557	48
Whirlpool	ET16JM*D*0*	16.4	557	48
Whirlpool	ET16JK*B*0*	16.4	557	48
Maytag	RTD17E0*A*	16.6	567	49
White-Westinghouse	WRT17*GC*1	16.8	581	50
Top freezer, automatic defrost, 17.5 - 18.4 cubic feet				
Hotpoint	CTH18EAX	18.2	518	45
Amana	TY18S4	17.8	551	48
Amana	TV18S4	17.9	551	48
Estate	TT18HA*D*0*	18.1	551	48
Kenmore	9658***	18.1	551	48
Kenmore	9758***	18.1	551	48
Kitchen Aid	KTH*18KD**0*	18.1	551	48
Roper	RT18HD*D*0*	17.9	551	48
Whirlpool	ET18HN*D*0*	17.9	551	48
Whirlpool	ET18HP*D*0*	18.2	551	48
Whirlpool	ET18HT*D*0*	18.1	551	48
Whirlpool	ET18SK*E*0*	17.9	551	48
Amana	T*18R3	17.8	582	50

Figure 6.10: Sample of equipment list (Wilson & Morrill, 1986:176)

6.16 MODELLING OUTPUTS

It has been noted that information from the system can be used as inputs into econometric and other models. These are usually used: to estimate the future demand for energy; to balance future expected supply and demand; to calculate emissions, or to quantify and evaluate different policy options. The outputs for

this aspect fall into two categories. The first is the extraction of information in a format that can be exported and used in a model not directly connected to the integrated system. The second involves the development of software modules residing within the system; extracting the required data directly, and then running the model as an integral component of the system. Outputs will depend on the method and structure selected and implemented.

6.17 TRAINING OUTPUTS

It is envisaged that the outputs from this section will provide the user with a list of organisations that provide formal training courses on energy topics. Details of course level, content, duration, certification, admission requirements and contact information will be available. Internet links to organisations will form part of the system. Some courses may well be offered in a distance learning format and it is possible that students may complete their studies through the medium of the Internet, using the energy information system as a 'textbook'.

6.18 POLICY OUTPUTS

Outputs from this area are envisaged as being primarily textual in nature and will include statements of national policy, legislation, regulations and other documents related directly to energy policy issues. There will be a close link to the bibliographic outputs. With careful selection of proprietary software tools and formats, electronic indexing to facilitate search capability to abstracts and full text documents could be a feature.

6.19 RURAL ENERGY OUTPUTS

Rural energy outputs will initially be textual in nature. As statistical data is added, so numerical information will become available. There are a number of aspects to rural energy that lend themselves to a GIS link. It is impossible to

define outputs before the policy maker provides guidance on data requirements to support rural energy policy formulation.

6.20 SYNTHESIS

The focus of this chapter has been on developing the framework for outputs from the system. Energy outputs, in both 'snapshot' and time series format, form the bulk of the analyses, and templates and examples have been provided in detail. Outputs where information is derived or calculated from data in different areas has been described generically and will only be detailed once the design specification is developed. The outputs were used to determine the data to be collected and included in the system. The system must be designed to be flexible to permit the definition and addition of widely disparate data. The use of metadata structures will be essential. Metadata is a database system concept defined as "..."data about data," through which the data are integrated..." (Rob & Coronel, 1997:4).

CHAPTER 7: CONCLUSIONS

7.1 LIMITATIONS OF STUDY

This study was limited to the conceptual development of an integrated national energy information system for South Africa. It was not possible to develop and implement a fully operational system, although a limited prototype was developed and run. A detailed assessment of the economic feasibility of full or partial implementation was also beyond the scope of this thesis. Nevertheless, estimations, concerns and indications were given.

The framework proposed here provides a solid foundation for the development and implementation of national or international systems. Portions of the conceptual design have, in fact, been used to develop a design specification for an integrated energy information system for SADC.

7.2 SUMMARY

The underlying assumption of this thesis is that information is critical for effective energy policy support. The objectives set and attained for this study were to:

- assess existing solutions to the problem of supplying energy information;
- consider developments in integrated conceptual solutions to the problems;
- identify and analyse data structures for providing a single integrated information system as a solution;
- evaluate and identify local energy and economic data sources for input to the proposed system;
- provide a framework for information outputs in such an integrated system; and
- make recommendations on the practical implementation of the conceptual solution.

The concepts underlying the basic assumption, and other parameters as set out in this thesis, were clarified in Chapter 1. In particular, the link between policy formulation, modelling, and data collection, management and dissemination was shown.

A study and assessment of existing energy information systems was then carried out. This investigated national systems in South Africa and other countries, and the systems of three international organisations. The structuring and management of these energy information systems was assessed, as was the degree to which each provided the necessary support for policy formulation. Legislation was also considered, where applicable. It was determined from this study and assessment that there were no integrated information systems to provide adequate information for energy policy makers through a single access point.

An integrated single access point system was postulated at the conceptual level in Chapter 3. The major contribution to this conceptualisation is the concept of a single standardised referential data set. A single referential data set can be used to classify all data at every level of the proposed integrated national energy information system. This integrated approach supports policy formulation and allows for the most efficient use of national resources in maintaining information. The proposed system was considered as a data flow model, to provide an overview of the collection, processing and dissemination of data. Next, a system model was developed. This divided the system into two broad divisions: the central control functions, including the referential data set; and the data modules, which provide the structure for capturing and maintaining the collected data. The final stage in this chapter was the development of a data model. It shows the relationships between the elements of the system model, particularly the relationship between the referential data set and all other data.

In Chapter 4, this data model was developed further to identify all of the entity sets or tables and their content descriptions. It indicates in tabular format the structure of the different system components, and then shows diagrammatically the high level linkages between these components. This analysis of the proposed system is the precursor to work by a systems analyst. Systems analysts are responsible for the final design specifications for system software when a system is commissioned.

In Chapter 5 the objective was to determine sources of data for input to the national system. The South African energy economy was briefly studied and assessed for both supply and demand side information.

Finally in Chapter 6, a set of output templates was developed. Once fully implemented, these should provide system users with all the necessary information to support policy formulation. Desired outputs from a system must be known (at least in general) before the system is designed, and are therefor included here.

7.3 IMPLICATIONS

It was postulated that an integrated national energy information system, with a single access point, would greatly facilitate policy formulation. If all national, and pertinent international, energy information were available via one system then governmental (and other's) information needs should be easily met. Research into the South African situation; other national energy information systems; and international organisations involved in energy, showed there are no operational fully integrated systems.

The above has two major implications. Firstly, as no integrated system exists, the implication is that either an integrated system is not possible or is not

desirable. The conceptual design for an integrated system presented in this thesis shows, however, that such a system is theoretically possible. While no national or international system is integrated, the desirability of integration is shown when more than one database or system is used to compile data into useful outputs. All the institutions assessed, when producing energy reports, balances, statistics, etc., needed at some point to access more than one system to extract all the required information. Implementing an integrated system would make analysts more effective in enabling them to devote more time to analyses rather than to the process of extracting data from different systems, aligning and recapturing the data before analysis can proceed. It was also shown that economic and financial benefits should accrue through the implementation of a well-planned integrated system. Ultimate benefits will depend on the extent to which the system is utilised.

All of which leads to the second major implication. If an integrated single access point system is both possible and desirable, the implication is that such a system is difficult to implement. The implications of implementation and any difficulties are thus addressed next.

Implementation of the proposed system requires two initial conditions. First, a central body responsible for setting up and running the system, and second, legislation to facilitate this. Centralised control and management of energy and related information collection, analysis and dissemination, is an obvious implication of a single national information system. Without legislation, however, implementation will still be virtually impossible. The need for both a central controlling body and data collection legislation imply governmental concern and backing, without which no integrated system can operate.

The IEA is an international organisation with an interest solely in energy, they are therefor a central controlling body and do not need government legislation to operate. Although their collection of data is dependent on

cooperation from national organisations, their processing and dissemination is not. Nevertheless they operate more than one database, and access these as needed for outputs. The EIA is the central energy body in the USA and has legislative backing, yet also operates multiple databases. There are a number of reasons for this worldwide state of affairs. Old systems, incompatible systems, lack of impetus and/or funding, difficulties in merging different data, different data attributes and the very large volumes of data are a few of these reasons.

All the reasons for not integrating existing systems into one (or not creating a new integrated system), devolve on one major problem. This is the difficulty of inputting data with differing attributes for extraction via a single access point. By implication, the proposed system must overcome this problem to be of value. A single referential data set at the centre of the control functions of the proposed system, is the core concept that will permit implementation of an integrated national energy information system. This concept is proposed and analysed in detail in the thesis.

After determining the referential data set for the system, and agreeing in principle to a central controlling body supported by legislation, one major consideration remains for implementation. Setting up a national system, as has been proposed in this thesis, is an expensive process - as is maintaining it. The final implication for the government on implementation is thus a need for continued long-term commitment to investment in developing expertise, in data collection programs, and in systems maintenance. These investments will be far greater than the initial investment in commissioning the system.

A schema of the stages of possible implementation are presented in Figure 7.1 below.

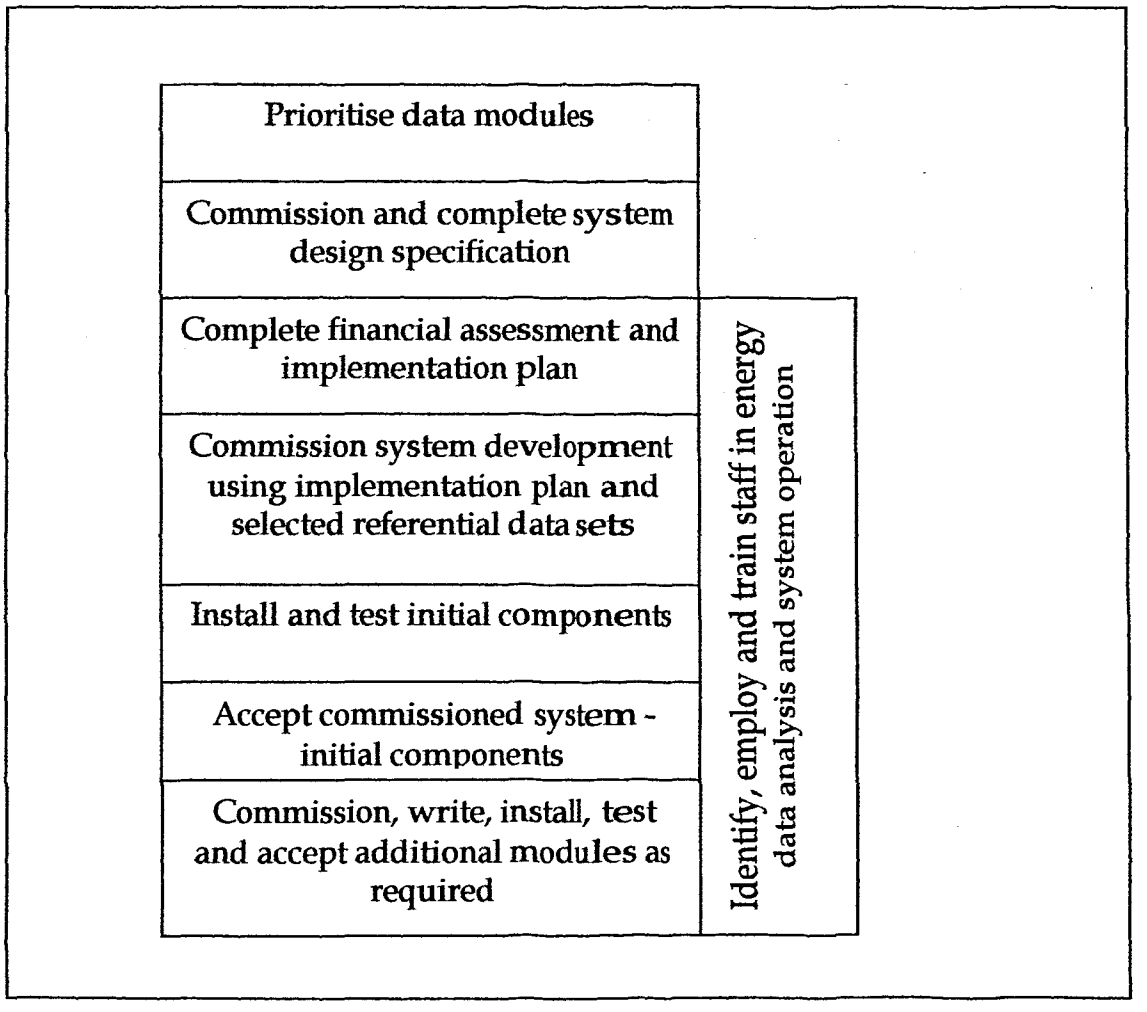

Figure 7.1: Schema for system implementation

7.4 RECOMMENDATIONS

Two levels of recommendations are given here. The first level is that of national government and the second is at individual organisation level.

Nationally, it is recommended that a centralised system for collecting information applicable to energy policy formulation be set up and operated as soon as possible. Even if no further use is made of the data at this time, later

availability of this historical data will be invaluable. Criteria for the data to be collected, by whom, and for what data attributes, can be taken from this thesis. Compliance with international emission standards will require data on current and historical emissions.

Current and future legislative needs for the facilitation of data collection and processing must be made at national level as well. In particular, this study determined a need for the legal enforcement of confidentiality to extend to non-governmental staff involved in official data collection efforts. The stricter enforcement of existing regulations regarding compliance in returning information must also be considered.

It is further recommended that the conceptual framework of this study be developed to create a fully operational integrated national energy information system. A central body, either independent or governmental, should be commissioned and empowered to implement this. The entire system, as envisaged here, need not be set up in one step. However, setting up the referential data set from this thesis for the entire system would be the first step. This would classify all data captured at any time, while additional modules etc., could be added to the system when required or possible. It is recommended that systems analysts use this thesis as a basis for software design.

On an individual, or non-national, level the collection and processing of energy data is an ongoing process by companies, institutions, researchers, and governmental organisations. Far from being discouraged, this data is crucial to national data requirements and should continue and expand. What would be of enormous assistance to national data resources is the collection and maintenance of this data in a unified format. The current situation, where research results and organisation records do not conform to standard formats or a referential framework, must be eliminated. Governmental

encouragement (or legislative pressure) is recommended, with dissemination and explanation of the necessary format requirements. These requirements are the same as those for the national system, as the recommendation is ultimately to incorporate this data into the national system.

7.5 PROPOSALS FOR CONTINUED RESEARCH

It is suggested that research be done into determining exactly what data is available in the DME library and archives that could be included in the system. Other data sources should also be identified and assessed. Data useful for inclusion in the national system will need to be classified by a standardised referential data set, as proposed in this study. The classification process itself requires research into feasible methods.

Detailed end-use studies will be very important in the collection of demand side data for inclusion in the proposed system. Identifying and prioritising industries for which this should be done will require some research. A formal data collection programme must be developed, and adhered to, with the goal of collecting all desired data on a regular basis. Surveys must be developed that capture all the required information, in a format that permits the seamless inclusion of results into the larger system. One research project that has been started is the extension of a boiler database for SA. This project can serve as prototype for equipment surveys.

It is proposed that serious study and research efforts should be directed at the use of GIS technology. This is a means of identifying the location of energy users, suppliers, infrastructure, projects and other attributes required to support policy formulation. Research into developing standard classification methods for GIS data should be considered. The environmental implications of national energy use also need to be researched and evaluated, and GIS can

play an important role in developing an understanding of these issues – as was briefly indicated in this study.

The need for environmental data linked to energy utilisation has become urgent. If international standards are enforced then SA will need to implement research projects in this area.

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APPENDIX A

SOUTH AFRICAN STANDARD INDUSTRIAL CLASSIFICATION SYSTEM (CSS, 1993)

Standard Industrial Classification Codings				
Division	Major group	Group	Sub-group	Title of category
11				AGRICULTURE, HUNTING AND RELATED SERVICES
	111			GROWING OF CROPS; MARKET GARDENING; HORTICULTURE
		1111	11110	Growing of cereals and other crops n.e.c.
		1112	11120	Growing of vegetables, horticultural specialities and nursery products
		1113	11130	Growing of fruit, nuts, beverage and spice crops
	112			FARMING OF ANIMALS
		1121	11210	Farming of cattle, sheep, goats, horses, asses, mules and hinnies, dairy farming
		1122	11220	Other animal farming; production of animal products n.e.c.
	113	1130	11300	GROWING OF CROPS COMBINES WITH FARMING OF ANIMALS (MIXED FARMING)
	114	1140	11400	AGRICULTURAL AND ANIMAL HUSBANDRY SERVICES, EXCEPT VETERINARY ACTIVITIES
	115			HUNTING, TRAPPING AND GAME PROPAGATION, INCLUDING RELATED SERVICES
		1151	11510	Game propagation
		1152	11520	Hunting and trapping, including related services
	116	1160	11600	PRODUCTION OF ORGANIC FERTILIZER
12				FORESTRY, LOGGING AND RELATED SERVICES
	121	1210	12100	FORESTRY AND RELATED SERVICES
	122	1220	12200	LOGGING AND RELATED SERVICES
13				FISHING, OPERATION OF FISH HATCHERIES AND FISH FARMS
	131	1310	13100	OCEAN AND COASTAL FISHING
	132	1320	13200	FISH HATCHERIES AND FISH FARMS
21	210	2100	21000	MINING OF COAL AND LIGNITE
22	221			EXTRACTION OF CRUDE PETROLEUM AND NATURAL GAS; SERVICE ACTIVITIES INCIDENTAL TO OIL AND GAS EXTRACTION
		2210	22100	Extraction of crude petroleum and natural gas
		2211	22110	Service activities incidental to oil and gas extraction, excluding surveying
23	230	2300	23000	MINING OF GOLD AND URANIUM ORE
24				MINING OF METAL ORES, EXCEPT GOLD AND URANIUM
	241	2410	24100	MINING OF IRON ORE
	242			MINING OF NON-FERROUS METAL ORES, EXCEPT GOLD AND URANIUM
		2421	24210	Chrome
		2422	24220	Copper
		2423	24230	Manganese
		2424	24240	Platinum group metals
		2429	24290	Other metal ore mining, except gold and uranium
25				OTHER MINING AND QUARRYING
	251			STONE QUARRYING, CLAY AND SAND-PITS
		2511	25110	Dimension stone (granite, slate, and wonderstone)
		2512	25120	Limestone and limeworks
		2519	25190	Other stone quarrying, including stone crushing and clay and sand-pits
	252	2520	25200	MINING OF DIAMONDS (INCLUDING ALLUVIAL DIAMONDS)
	253			MINING AND QUARRYING N.E.C.
		2531		Mining of chemical and fertilizer minerals
			25311	Phosphates
			25319	Other chemical and fertilizer mineral mining
		2532	25320	Extraction and evaporation of salt
		2539		Other mining and quarrying n.e.c.
			25391	Mining of precious and semi-precious stones, except diamonds
			25392	Asbestos
			25399	Other minerals and materials n.e.c.
29	290	2900	29000	SERVICE ACTIVITIES INCIDENTAL TO MINING OF MINERALS
30				MANUFACTURE OF FOOD PRODUCTS, BEVERAGES AND TOBACCO PRODUCTS
	301			PRODUCTION, PROCESSING AND PRESERVATION OF MEAT, FISH, FRUIT, VEGETABLES, OILS AND FAT
		3011		Production, processing and preserving of meat and meat products
			30111	Slaughtering, dressing and packing of livestock, including poultry and small game for meat
			30112	Manufacture of prepared and preserved meat, including sausage; by-products (hides, bones etc.)
			30113	Production of lard and other edible fats
		3012		Processing and preserving of fish and fish products
			30120	Manufacture of canned, preserved and processed fish, crustacea and similar foods (except soups)
		3013		Processing and preserving of fruit and vegetables
			30130	Manufacture of canned, preserved, processed and dehydrated fruit and vegetables (except soups), including fruit juices, juice extracts an
		3014		Manufacture of vegetable and animal oils and fats
			30141	Manufacture of crude oil and oilseed cake and meal
			30142	Manufacture of compound and cooking fat, margarine and edible oils
	302	3020		MANUFACTURE OF DAIRY PRODUCTS
			30201	Processing of fresh milk (pasteurizing, homogenising, sterilising and vitaminising)
			30202	Manufacture of butter and cheese
			30203	Manufacture of ice cream and other edible ice, whether or not containing cream of chocolate
			30204	Manufacture of milk powder, condensed milk and other edible milk products, e.g. ghee, casein or lactose
	303			MANUFACTURE OF GRAIN MILL PRODUCTS, STARCHES AND STARCH PRODUCTS AND PREPARED ANIMAL FEEDS
		3031		Manufacture of grain mill products
			30311	Manufacture of flour and grain mill products, including rice and vegetable milling; grain mill residues

Division	Major group	Group	Sub-group	Title of category
			30312	Manufacture of breakfast foods
		3032	30320	Manufacture of starches and starch products
		3033	30330	Manufacture of prepared animal feeds
	304			MANUFACTURE OF OTHER FOOD PRODUCTS
		3041	30410	Manufacture of bakery products
		3042	30420	Manufacture of sugar, including golden syrup and castor sugar
		3043	30430	Manufacture of cocoa, chocolate and sugar confectionery
		3044	30440	Manufacture of macaroni, noodles, couscous and similar farinaceous products
		3049		Manufacture of other food products n.e.c.
			30491	Manufacture of coffee, coffee substitutes and tea
			30492	Manufacture of nut foods
			30499	Manufacture of spices, condiments, vinegar, yeast, egg products, soups and other food products n.e.c.
	305			MANUFACTURE OF BEVERAGES
		3051	30510	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials; manufacture of wine
		3052		Manufacture of beer and other malt liquors and malt
			30521	Breweries, except sorghum beer breweries
			30522	Sorghum beer breweries
			30523	Manufacture of malt
		3053	30530	Manufacture of soft drinks; production of mineral waters
	306	3060	30600	MANUFACTURE OF TOBACCO PRODUCTS
31				MANUFACTURE OF TEXTILES, CLOTHING AND LEATHER GOODS
	311			SPINNING, WEAVING AND FINISHING OF TEXTILES
		3111		Preparation and spinning of textile fibers; weaving of textiles
			31111	Preparatory activities in respect of animal fibres, including washing combining and carding of wool
			31112	Preparatory activities in respect of vegetable fibres
			31113	Spinning, weaving and finishing of yarns and fabrics predominantly of wool and other animal fibres
			31114	Spinning, weaving and finishing of yarns and fabrics predominantly of vegetable fibres
		3112		Finishing of textiles
			31120	Finishing of purchased yarns and fabrics
	312			MANUFACTURE OF OTHER TEXTILES
		3121		Manufacture of made-up textile articles, except apparel
			31211	Manufacture of blankets, made-up furnishing articles and stuffed articles
			31212	Manufacture of tents, tarpaulins, sails and other canvas goods
			31213	Manufacture of automotive textile goods (including safety belts, seat covers and upholstery)
			31219	Manufacture of other textile articles (except apparel)
		3122	31220	Manufacture of carpets, rugs and mats
		3123	31230	Manufacture of cordage, rope, twine and netting
		3129	31290	Manufacture of other textiles n.e.c.
	313	3130		MANUFACTURE OF KNITTED AND CROCHETED FABRICS AND ARTICLES
			31301	Garment and hosiery knitting mills
			31309	Other knitting mills
	314	3140		MANUFACTURE OF WEARING APPAREL, EXCEPT FUR APPAREL
			31401	Manufacture of men's and boys' clothing
			31402	Manufacture of women's, girls' and infants' clothing
			31403	Bespoke tailoring
			31404	Manufacture of hats, caps and ties
	315	3150		DRESSING AND DYEING OF FUR; MANUFACTURE OF ARTICLES OF FUR
			31500	Dressing and dyeing of fur, manufacture of artificial fur, fur apparel and other articles of fur
	316			TANNING AND DRESSING OF LEATHER; MANUFACTURE OF LUGGAGE, HANDBAGS, SADDLERY AND HARNESS
		3161	31610	Tanning and dressing of leather
		3162		Manufacture of luggage, handbags and the like, saddlery and harness
			31621	Manufacture of travel goods and ladies' handbags
			31629	Manufacture of other general and small goods of leather and leather substitutes, including harness and saddlery
	317	3170	31700	MANUFACTURE OF FOOTWEAR
32				MANUFACTURE OF WOOD AND OF PRODUCTS OF WOOD AND CORK, EXCEPT FURNITURE; MANUFACTURE OF ARTICLES
	321	3210		SAWMILLING AND PLANING OF WOOD
			32101	Sawmilling and preserving of timber
			32109	Other mill products, including wattle bark grinding and compressing
	322			MANUFACTURE OF PRODUCTS OF WOOD, CORK, STRAW AND PLAITING MATERIALS
		3221	32210	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board and other panels and boards
		3222	32220	Manufacture of builders' carpentry and joinery
		3223	32230	Manufacture of wooden containers
		3229		Manufacture of other products of wood, manufacture of articles of cork, straw and plaiting materials
			32291	Coffins (excluding the manufacture of coffins by funeral undertakers)
			32292	Picture frames and framing
			32299	Other articles of wood, cork, straw and plaiting materials, including woodcarving and woodturning
		3231	32310	Manufacture of pulp, paper and paperboard
		3232		Manufacture of corrugated paper and paperboard and containers of paper and paperboard
			32321	Manufacture of corrugated paper and paperboard
			32322	Manufacture of containers of paper and paperboard
		3239		Manufacture of other articles of paper and paperboard
			32391	Stationery

Division	Major group	Group	Sub-group	Title of category
			32399	Other paper products
	324			PUBLISHING
		3241	32410	Publishing of books, brochures, musical books and other publications
		3242	32420	Publishing of newspapers, journals and periodicals
		3243	32430	Publishing of recorded media
		3249	32490	Other publishing
	325			PRINTING AND SERVICE ACTIVITIES RELATED TO PRINTING
		3251	32510	Printing
		3252	32520	Service activities related to printing
	326	3260	32600	REPRODUCTION OF RECORDED MEDIA
33				MANUFACTURE OF COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL; MANUFACTURE OF CHEMICALS AND C
	331	3310	33100	MANUFACTURE OF COKE AND OTHER PRODUCTS
	332			PETROLEUM REFINERIES/SYNTHESISERS
		3321	33210	Petrol, fuel oils, lubricating oils and greases, primarily from crude oil
		3322	33220	Petrol, fuel oils, lubricating oils and greases, primarily from coal
		3323	33230	Petrol, fuel oils, lubricating oils and greases, primarily from natural gas
		3324	33240	Lubricating oils and greases, primarily from other organic products
		3325	33250	Compounded and blended lubricating oils and greased from purchased materials other than crude petroleum
		3329	33290	Other petroleum/synthesised products n.e.c.
	333	3330	33300	PROCESSING OF NUCLEAR FUEL
	334			MANUFACTURE OF BASIC CHEMICALS
		3341	33410	Manufacture of basic chemicals, except fertilizers and nitrogen compounds
		3342	33420	Manufacture of fertilizers and nitrogen compounds
		3343	33430	Manufacture of plastics in primary form and of synthetic rubber
	335			MANUFACTURE OF OTHER CHEMICAL PRODUCTS
		3351	33510	Manufacture of pesticides and other agro-chemical products
		3352	33520	Manufacture of paints, varnishes and similar coatings, printing inks and mastics
		3353	33530	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
		3354		Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
			33541	Manufacture of soap and other cleaning compounds
			33542	Manufacture of perfumes, cosmetics and other toilet preparations
			33549	Manufacture of other preparations such as polishes, waxes and dressings
		3359		Manufacture of other chemical products n.e.c.
			33591	Manufacture of edible salt
			33592	Manufacture of explosives and pyrotechnic products
			33593	Manufacture of adhesives, glues, sizes and cements
			33599	Manufacture of other chemical products n.e.c.
	336	3360	33600	MANUFACTURE OF MAN-MADE FIBRES
	337			MANUFACTURE OF RUBBER PRODUCTS
		3371		Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
			33711	Manufacture of tyres and tubes
			33712	Rebuilding and retreading of tyres
		3379	33790	Manufacture of other rubber products
	338	3380	33800	MANUFACTURE OF PLASTIC PRODUCTS
34				MANUFACTURE OF OTHER NON-METALLIC MINERAL PRODUCTS
	341	3411		MANUFACTURE OF GLASS AND GLASS PRODUCTS
			34111	Manufacture of sheet and plate glass, glass blocks, tubes and rods; glass fibres and glass wool
			34112	Manufacture of glass containers; glass kitchenware and tableware, scientific and laboratory glassware, clock and watch glasses and othe
	342			MANUFACTURE OF NON-METALLIC MINERAL PRODUCTS N.E.C.
		3421	34210	Manufacture of non-structural non-refractory ceramicware
		3422	34220	Manufacture of refractory ceramic products
		3423	34230	Manufacture of structural non-refractory clay and ceramic products
		3424	34240	Manufacture of cement, lime and plaster
		3425	34250	Manufacture of articles of concrete cement and plaster
		3426	34260	Cutting, shaping and finishing of stone
		3429		Manufacture of other non-metallic mineral products n.e.c.
			34291	Abrasives
			34299	Other non-metallic mineral products n.e.c.
35				MANUFACTURE OF BASIC METALS, FABRICATED METAL PRODUCTS, MACHINERY AND EQUIPMENT AND OF OFFICE, ACCO
	351	3510		MANUFACTURE OF BASIC IRON AND STEEL
			35101	Basic iron and steel industries, except steel pipe and tube mills
			35102	Steel pipe and tube mills
	352	3520		MANUFACTURE OF BASIC PRECIOUS AND NON-FERROUS METALS
			35201	Refining of precious metals, e.g. gold, silver, platinum
			35202	Manufacture of primary non-ferrous metal products, excluding precious metals
	353			CASTING OF METALS
		3531	35310	Casting of iron and steel of cutlery, hand tools and general hardware
		3532	35320	Casting of non-ferrous metals
	354			MANUFACTURE OF STRUCTURAL METAL PRODUCTS, TANKS, RESERVOIRS AND STEAM GENERATORS
		3541		Manufacture of structural metal products
			35411	Manufacture of metal structures or parts thereof
			35419	Other structural metal products e.g. metal doors, windows and gates

Division	Major group	Group	Sub-group	Title of category
		3542	35420	Manufacture of tanks, reservoirs and similar containers of metal
		3543	35430	Manufacture of steam generators, except central heating hot water boilers
	355			MANUFACTURE OF OTHER FABRICATED METAL PRODUCTS; METALWORK SERVICE ACTIVITIES
		3551	35510	Forging, pressing, stamping and roll-forming of metal; powder metallurgy
		3552		Treatment and coating of metals; general mechanical engineering on a fee or contract basis
			35521	Treating and coating of metals
			35522	General mechanical engineering on a fee or contract basis
		3553	35530	Manufacture of cutlery, hand tools and general hardware
		3559		Manufacture of other fabricated metal products n.e.c.
			35591	Manufacture of metal containers, e.g. cans and tins
			35592	Manufacture of cables and wire products
			35593	Manufacture of springs (all types)
			34494	Manufacture of metal fastners
			35599	Manufacture of other metal products n.e.c.
	356			MANUFACTURE OF GENERAL PURPOSE MACHINERY
		3561	35610	Manufacture of engines and turbines, except aircraft, vehicle and motor cycle engines
		3562	35620	Manufacture of pumps, compressors, taps and valves
		3563	35630	Manufacture of bearings, gears, gearing and driving elements
		3564	35640	Manufacture of ovens, furnaces and furnace burners
		3565	35650	Manufacture of lifting and handling equipment
		3569	35690	Manufacture of other general purpose machinery
	357			MANUFACTURE OF SPECIAL PURPOSE MACHINERY
		3571	35710	Manufacture of agricultural and forestry machinery
		3572	35720	Manufacture of machine tools
		3573	35730	Manufacture of machinery for metallurgy
		3574	35740	Manufacture of machinery for mining quarrying and construction
		3575	35750	Manufacture of machinery for food, beverage and tobacco processing
		3576	35760	Manufacture of machinery for textile, apparel and leather production
		3577	35770	Manufacture of weapons and ammunition
		3579	35790	Manufacture of other special purpose machinery
	358	3580	35800	MANUFACTURE OF HOUSEHOLD APPLIANCES N.E.C.
	359	3590	35900	MANUFACTURE OF OFFICE, ACCOUNTING AND COMPUTING MACHINERY
36				MANUFACTURE OF ELECTRICAL MACHINERY AND APPARATUS N.E.C.
	361	3610	36100	MANUFACTURE OF ELECTRIC MOTORS, GENERATORS AND TRANSFORMERS
	362	3620	36200	MANUFACTURE OF ELECTRICITY DISTRIBUTION AND CONTROL APPARATUS
	363	3630	36300	MANUFACTURE OF INSULATED WIRE AND CABLE
	364	3640	36400	MANUFACTURE OF ACCUMULATORS, PRIMARY CELLS, AND PRIMARY BATTERIES
	365	3650		MANUFACTURE OF ELECTRIC LAMPS AND LIGHTING EQUIPMENT
			36501	Manufacture of electric bulbs and fluorescent tubes
			36502	Manufacture of illuminated signs and advertising displays
			36503	Manufacture of lamps and lampshades
	366	3660	36600	MANUFACTURE OF OTHER ELECTRICAL EQUIPMENT N.E.C.
37				MANUFACTURE OF RADIO, TELEVISION AND COMMUNICATION EQUIPMENT AND APPARATUS AND OF MEDICAL, PRECISIO
	371	3710	37100	MANUFACTURE OF ELECTRONIC VALVES AND TUBES AND OTHER ELECTRONIC COMPONENTS
	372	3720	37200	MANUFACTURE OF TELEVISION AND RADIO TRANSMITTERS AND APPARATUS FOR LINE TELEPHONY AND LINE TELEGRAP
	373	3730	37300	MANUFACTURE OF TELEVISION AND RADIO RECEIVERS SOUND OR VIDEO RECORDING OR REPRODUCING APPARATUS A
	374			MANUFACTURE OF MEDICAL APPLIANCES AND INSTRUMENTS AND APPLIANCES FOR MEASURING , CHECKING, TESTING,
		3741		Manufacture of medical and surgical equipment and orthopaedic appliances
			37411	Orthopaedic appliances
			37412	Surgical, medical and dental supplies
		3742	37420	Manufacture of instruments and appliances for measuring, checking, testing, navigating and for other purposes, except industrial process
		3743	37430	Manufacture of industrial process control equipment
	375	3750	37500	MANUFACTURE OF OPTICAL INSTRUMENTS AND PHOTOGRAPHIC EQUIPMENT
	376	3760	37600	MANUFACTURE OF WATCHES AND CLOCKS
38				MANUFACTURE OF TRANSPORT EQUIPMENT
	381	3810	38100	MANUFACTURE OF MOTOR VEHICLES
	382	3820	38200	MANUFACTURE OF BODIES (COACHWORK) FOR MOTOR VEHICLES; MANUFACTURE OF TRAILERS AND SEMI-TRAILERS
	383	3830		MANUFACTURE OF PARTS AND ACCESSORIES FOR MOTOR VEHICLES AND THEIR ENGINES
			38301	Manufacture of radiators
			38302	Activities of specialised automotive engineering workshops working primarily for the motor trade
			38309	Manufacture of other motor vehicle parts and accessories
	384			BUILDING AND REPAIRING OF SHIPS AND BOATS
		3841	38410	Building and repairing of ships
		3842	38420	Building and repairing of pleasure and sporting boats
	385	3850	38500	MANUFACTURE OF RAILWAY AND TRAMWAY LOCOMOTIVES AND ROLLING STOCK
	386	3860	38600	MANUFACTURE OF AIRCRAFT AND SPACECRAFT
	387			MANUFACTURE OF TRANSPORT EQUIPMENT N.E.C.
		3871	38710	Manufacture of motor cycles
		3872	38720	Manufacture of bicycles and invalid carriages
		3879	38790	Manufacture of other transport equipment n.e.c.
39				MANUFACTURE OF FURNITURE, MANUFACTURING N.E.C. RECYCLING
	391	3910		MANUFACTURE OF FURNITURE

Division	Major group	Group	Sub-group	Title of category
			39101	Manufacture of furniture made predominantly of metal
			39102	Manufacture of furniture made predominantly of plastic materials
			39103	Manufacture of furniture made predominantly of materials other than metal, plastic or concrete
	392			MANUFACTURING N.E.C.
		3921		Manufacture of jewellery and related articles
			39211	Jewellery and related articles composed of precious metals, precious and semi-precious stones and pearls
			39212	Diamond cutting and polishing
			39219	Other precious and semi-precious stone cutting and polishing
		3922	39220	Manufacture of musical instruments
		3923	39230	Manufacture of sports goods
		3924	39240	Manufacture of games and toys
		3929		Other manufacturing n.e.c.
			39291	Brushes and brooms
			39292	Crayons, chalk, pens and pencils
			39293	Buttons, buckles, slide fastners, etc.
			39294	Number plates, signs and advertising displays, that are not electrical
			39295	Pattern-making other than paper patterns
			39296	Engraving
			39299	Other industries not elsewhere classified, including rubber stamps, taxidermists, ostrich feathers, costume jewellery and novelties, umbrel
	395			RECYCLING N.E.C.
		3951	39510	Recycling of metal waste and scrap n.e.c.
		3952	39520	Recycling of non-metal waste and scrap n.e.c.
41				ELECTRICITY, GAS, STEAM AND HOT WATER SUPPLY
	411	4111		Production, collection and distribution of electricity
			41111	Generation
			41112	Distribution of purchased electric energy only
			41113	Generation and/or distribution for own use
	412	4120	41200	Manufacture of gas; distribution of gaseous fuels through mains
	413	4130	41300	Steam and hot water supply
42	420	4200	42000	COLLECTION, PURIFICATION AND DISTRIBUTION OF WATER
50				CONSTRUCTION
	501	5010	50100	SITE PREPARATION
	502			BUILDING OF COMPLETE CONSTRUCTIONS OR PARTS THEREOF; CIVIL ENGINEERING
		5021		Construction of buildings
			50211	Construction of homes
			50219	Construction of other buildings
		5022	50220	Construction of civil engineering structures
		5023	50230	Construction of other structures
		5024	50240	Construction by specialist trade contractors
	503			BUILDING INSTALLATION
		5031	50310	Plumbing
		5032	50320	Electrical contracting
		5033	50330	Shopfitting
		5039	50390	Other building installation n.e.c.
	504			BUILDING COMPLETION
		5041	50410	Painting and decorating
		5049	50490	Other building completion n.e.c.
	505	5050	50500	RENTING OF CONSTRUCTION OR DEMOLITION EQUIPMENT WITH OPERATORS
61				WHOLESALE AND COMMISSION TRADE, EXCEPT OF MOTOR VEHICLES AND MOTOR CYCLES
	611	6110		WHOLESALE TRADE ON A FEE OR CONTRACT BASIS
			61101	Sales by commission agents
			61102	Sales by commodity brokers
			61103	Sales by auctioneers
			61109	Other wholesale trade on a fee or contract basis
	612			WHOLESALE TRADE IN AGRICULTURAL RAW MATERIALS, LIVESTOCK, FOOD, BEVERAGES AND TOBACCO
		6121	61210	Wholesale trade in agricultural raw materials and livestock
		6122		Wholesale trade in food, beverages and tobacco
			61221	Wholesale trade in foodstuffs
			61222	Wholesale trade in beverages
			61223	Wholesale trade in tobacco products
	613			WHOLESALE TRADE IN HOUSEHOLD GOODS
		6131	61310	Wholesale trade in textiles, clothing and footwear
		6139		Wholesale trade in other household goods
			61391	Wholesale trade in household furniture, requisites and appliances
			61392	Wholesale trade in books and stationery
			61393	Wholesale trade in precious stones, jewellery and silverware
			61394	Wholesale trade in pharmaceuticals and toiletries
			61399	Wholesale trade in other household goods n.e.c.
	614			WHOLESALE TRADE IN NON-AGRICULTURAL INTERMEDIATE PRODUCTS, WASTE AND SCRAP
		6141	61410	Wholesale trade in solid, liquid and gaseous fuels and related products
		6142	61420	Wholesale trade in metals and metal ores
		6143	61430	Wholesale trade in construction materials, hardware, plumbing and heating equipment and supplies

Division	Major group	Group	Sub-group	Title of category
		6149	61490	Wholesale trade in other intermediate products, waste and scrap
	615	6150		WHOLESALE TRADE IN MACHINERY, EQUIPMENT AND SUPPLIES
			61501	Office machinery and equipment including computers
			61509	Other machinery
	619	6190		OTHER WHOLESALE TRADE
			61901	General wholesale trade
			61909	Other wholesale trade n.e.c.
62				RETAIL TRADE, EXCEPT MOTOR VEHICLES AND MOTOR CYCLES, REPAIR OF PERSONAL AND HOUSEHOLD GOODS
	621			NON-SPECIALISED RETAIL TRADE IN STORES
		6211	62110	Retail trade in non-specialised stores with food, beverages and tobacco predominating
		6219	62190	Other retail trade in non-specialised stores
	622	6220		RETAIL TRADE IN FOOD, BEVERAGES AND TOBACCO IN SPECIALISED STORES
			62201	Retail trade in fresh fruit and vegetables
			62202	Retail trade in meat and meat products
			62203	Retail trade in bakery products
			62204	Retail trade in beverages (bottle stores)
			62209	Other retail trade in food, beverages and tobacco n.e.c.
	623			OTHER RETAIL TRADE IN NEW GOODS IN SPESIALISED STORES
		6231	62310	Retail trade in pharmaceutical and medical goods, cosmetics and toilet articles
		6232		Retail trade in textiles, clothing, footwear and leather goods
			62321	Retail trade in men's and boys' clothing
			62322	Retail trade in ladies' and girls' clothing
			62323	Retail trade by general outfitters and by dealers in piece goods, textiles, leather and travel accessories
			62324	Retail trade in shoes
		6233	62330	Retail trade in household furniture, appliances, articles and equipment
		6234	62340	Retail trade in hardware, paints and glass
		6239		Other retail trade in specialised stores
			62391	Retail trade in reading matter and stationery
			62392	Retail trade in jewellery, watches and clocks
			62393	Retail trade in sports goods and entertainment requisites
			62399	Retail trade by other specialised stores
	624	6240	62400	RETAIL TRADE IN SECOND-HAND GOODS IN STORES
	625			RETAIL TRADE NOT IN STORES
		6251		Retail trade in via mail-order houses
			62511	Retail trade in books via mail-order houses
			62519	Other retail trade via mail-order houses
		6252	62520	Retail trade via stalls and markets
		6259	62590	Other retail trade not in stores
	626	6260		REPAIR PERSONAL AND HOUSEHOLD GOODS
			62601	Repair of footwear and leather goods
			62602	Repair, servicing and installation of household and personal appliances
			62609	Other repair services for the general public, n.e.c.
63				SALE, MAINTENANCE AND REPAIR OF MOTOR VEHICLES AND MOTOR CYCLES; RETAIL TRADE IN AUTOMOTIVE FUEL
	631			SALE OF MOTOR VEHICLES
		6311	63110	Wholesale sale of motor vehicles
		6312		Retail sale of motor vehicles
			63121	Retail sale of new motor vehicles
			63122	Retail sale of used motor vehicles
	632	6320		MAINTENANCE AND REPAIR OF MOTOR VEHICLES
			63201	General repairs
			63202	Electrical repairs
			63203	Radiator repairs
			63204	Body repairs
			63209	Other maintenance and repairs n.e.c.
	633			SALE OF MOTOR VEHICLE PARTS AND ACCESSORIES
		6331		Sale of new parts and accessories
			63311	Sale of tyres
			63319	Sale of other new parts and accessories
		6332	63320	Sale of used parts and accessories
	634	6340	63400	SALE, MAINTENANCE AND REPAIR OF MOTOR CYCLES AND RELATED PARTS AND ACCESSORIES
	635	6350	63500	RETAIL SALE OF AUTOMOTIVE FUEL
64				HOTELS AND RESTAURANTS
	641	6410		HOTELS, CAMPING SITES AND OTHER PROVISION OF SHORT-SAY ACCOMMODATION
			64101	Hotels, motels, botels and inns registered with the SA Tourism Board
			64102	Caravan parks and camping sites
			64103	Guest-houses and guest-farms
			64109	Other accommodation n.e.c.
	642	6420		RESTAURANTS, BARS AND CANTEENS
			64201	Restaurants or tearooms with liquor licence
			64202	Restaurants or tearooms without liquor licence
			64203	Take-away counters
			64204	Caterers

Division	Major group	Group	Sub-group	Title of category
			64209	Other catering services n.e.c.
71				LAND TRANSPORT; TRANSPORT VIA PIPE LINES
	711	7111		RAILWAY TRANSPORT
			71111	Inter-urban railway transport
			71112	Railway commuter services
	712			OTHER LAND TRANSPORT
		7121		Other scheduled passenger land transport
			71211	Urban, sub-urban and inter-urban bus and coach passenger lines
			71212	School buses
		7122		Other non-scheduled passenger land transport
			71221	Taxis
			71222	Safaris and sightseeing bus tours
			71229	Other passenger transport, including the renting of motor cars with drivers
		7123		Freight transport by road
			71231	Transport of furniture
			71239	Other freight transport by road
	713	7130	71300	TRANSPORT VIA PIPELINES
72				WATER TRANSPORT
	721	7211		SEA AND COASTAL WATER TRANSPORT
			72111	Coastal shipping
			72112	Ocean shipping
	722	7220	72200	INLAND WATER TRANSPORT
73				AIR TRANSPORT
	730	7300	73000	AIR TRANSPORT
74	741			SUPPORTING AND AUXILIARY TRANSPORT ACTIVITIES; ACTIVITIES OF TRAVEL AGENCIES
		7411	74110	Cargo handling
		7412	74120	Storage and warehousing
		7413		Other supporting transport activities
			74131	Parking garages and parking lots
			74132	Salvaging of distressed vessels and cargoes
			74133	Maintenance and operation of harbour works, lighthouses, etc., pilotage
			74134	Operation of airports, flying fields and air navigation facilities
			74135	Operation of roads and toll roads
			74139	Other supporting transport activities n.e.c.
		7414	74140	Travel agency and related activities
		7419	74190	Activities of other transport agencies
75				POSTAL AND TELECOMMUNICATION
	751			POSTAL AND RELATED COURIER ACTIVITIES
		7511	75110	National postal activities
		7512	75120	Courier activities other than national postal activities
	752	7520	75200	TELECOMMUNICATION
81				FINANCIAL INTERMEDIATION, EXCEPT INSURANCE AND PENSION FUNDING
	811	8111		MONETARY INTERMEDIATION
			81110	Central banking
		8112		Other monetary intermediation
			81121	Discount houses and commercial and other banking
			82222	Building society activities
	819			OTHER FINANCIAL INTERMEDIATION N.E.C.
		8191	81910	Lease finance
		8192	81920	Other credit granting
		8199	81990	Other financial intermediation n.e.c.
82				INSURANCE AND PENSION FUNDING, EXCEPT COMPULSORY SOCIAL SECURITY
		8211	82110	Life insurance
		8212	82120	Pension funding
		8213	82130	Medical aid funding
		8219	82190	Other insurance n.e.c.
83				ACTIVITIES AUXILIARY TO FINANCIAL INTERMEDIATION
	831			ACTIVITIES AUXILIARY TO FINANCIAL INTERMEDIATION, EXCEPT INSURANCE AND PENSION FUNDING
		8311	83110	Administration of financial markets
		8312	83120	Security dealing activities
		8319	83190	Activities auxiliary to financial intermediation n.e.c.
	832			ACTIVITIES AUXILIARY TO INSURANCE AND PENSION FUNDING
		8320	83200	Activities auxiliary to insurance and pension funding
84				REAL ESTATE ACTIVITIES
	841			REAL ESTATE ACTIVITIES WITH OWN OR LEASED PROPERTY
		8411	84110	Property owning and letting
		8412	84120	Developing real estate, subdividing real estate into lots and residential developments on own account
		8413	84130	Owning and/or sale of fixed property
	842			REAL ESTATE ACTIVITIES ON A FEE OR CONTRACT BASIS
		8421	84210	Activities of estate agencies, rent collectors, appraisers and valuers
		8422	84220	Subletting of fixed property
85				RENTING OF MACHINERY AND EQUIPMENT, WITHOUT OPERATOR AND OF PERSONAL AND HOUSEHOLD GOODS

Division	Major group	Group	Sub-group	Title of category
	851			RENTING OF TRANSPORT EQUIPMENT
		8511	85110	Renting of land transport equipment
		8512	85120	Renting of water transport equipment
		8513	85130	Renting of air transport equipment
	852			RENTING OF OTHER MACHINERY AND EQUIPMENT
		8521	85210	Renting of agricultural machinery and equipment
		8522	85220	Renting of construction and civil engineering machinery and equipment
		8523	85230	Renting of office machinery and equipment (including computers)
		8529	85290	Renting of other machinery and equipment n.e.c.
	853			RENTING OF PERSONAL AND HOUSEHOLD GOODS N.E.C.
		8530	85300	Renting of personal and household goods n.e.c.
86				COMPUTER AND RELATED ACTIVITIES
	861	8610	86100	HARDWARE CONSULTANCY
	862	8620	86200	SOFTWARE CONSULTANCY AND SUPPLY
	863	8630	86300	DATA PROCESSING
	864	8640	86400	DATA BASE ACTIVITIES
	865	8650	86500	MAINTENANCE AND REPAIR OF OFFICE ACCOUNTING AND COMPUTING MACHINERY
	869	8690	86900	OTHER COMPUTER RELATED ACTIVITIES
87				RESEARCH AND DEVELOPMENT
	871			RESEARCH AND EXPERIMENTAL DEVELOPMENT ON NATURAL SCIENCES AND ENGINEERING
		8711	87110	General research, e.g. CSIR
		8712	87120	Agricultural and livestock research
		8713	87130	Medical and veterinary research e.g. S.A. Medical Research Council
		8714	87140	Industrial research, e.g. fuel research
		8719	87190	Other research n.e.c.
	872	8720	87200	RESEARCH AND EXPERIMENTAL DEVELOPMENT ON SOCIAL SCIENCES AND HUMANITIES
88				OTHER BUSINESS ACTIVITIES
	881			LEGAL, ACCOUNTING, BOOKKEEPING AND AUDITING ACTIVITIES; TAX CONSULTANCY; MARKET RESEARCH AND PUBLIC O
		8811		Legal activities
			88111	Activities of attorneys, notaries and conveyancers
			88112	Activities of advocates
		8812		Accounting, bookkeeping and auditing activities; tax consultancy
			88121	Activities of accountants and auditors registered in terms of the Public Accountants and Auditors Act
			88122	Activities of cost and management accountants
			88123	Bookkeeping activities, including relevant data processing and tabulating activities
		8813	88130	Marketing research and public opinion polling
		8814	88140	Business and management consultancy activities
	882			AGRICULTURAL, ENGINEERING AND OTHER TECHNICAL ACTIVITIES
		8821		Architectural and engineering activities and related technical consultancy
			88211	Consulting engineering activities
			88212	Architectural activities
			88213	Activities of quantity surveyors
			88214	Activities of land surveyors
			88215	Geological and prospecting activities on a fee or contract basis
			88216	Activities of non-registered architects, e.g. tracers and draughtsmen of plans for dwellings
		8822		Technical testing and analysis
			88220	Other activities - engineering and other commercial research - developing and testing - e.g. SABS
	883	8831		ADVERTISING
			88311	Activities of advertising agents
			88312	Signwriting and industrial and commercial artistry
	889			BUSINESS ACTIVITIES N.E.C.
		8891		Labour recruitment and provision of staff
			88911	Activities of employment agencies and recruiting organisations
			88912	Hiring out of workers (labourbroking activities)
		8892	88920	Investigation and security activities
		8893	88930	Building and industrial plant cleaning activities
		8894	88940	Photographic activities
		8895	88950	Packaging activities
		8899		Other business activities n.e.c.
			88991	Credit rating agency activities
			88992	Debt collecting agency activities
			88993	Stenographic, duplicating, addressing, mailing list and similar activities
			88999	Other business activities n.e.c.
91				PUBLIC ADMINISTRATION AND DEFENCE ACTIVITIES
	911	9110		CENTRAL GOVERNMENT ACTIVITIES
			91101	Government departments
			91102	Provincial administrations
			91103	Self-governing territories and their lower authorities
			91109	Other Central Government activities
	912	9120	91200	REGIONAL SERVICES COUNCIL ACTIVITIES
	913	9130	91300	LOCAL AUTHORITY ACTIVITIES
92				EDUCATION

Division	Major group	Group	Sub-group	Title of category
	920	9200		EDUCATIONAL SERVICES
			92001	Pre-primary education and activities of after-school centres
			92002	Pre-primary and secondary education
			92003	Special education and training of mentally retarded children
			92004	Education by technical colleges and technical institutions
			92005	Education by technikons
			92006	Education by teachers' training colleges and colleges of education for further training
			92007	Education by universities
			92008	Education by correspondence and private vocational colleges
			92009	Other educational services - own account teachers, motor vehicle driving schools/tutors and music, dancing and other art schools, etc.
93				HEALTH AND SOCIAL WORK
	931			HUMAN HEALTH ACTIVITIES
		9311		Hospital activities
			93111	General hospitals
			93112	Maternity homes
			93113	Tuberculosis hospitals
			93114	Psychiatric hospitals
			93115	Detached operation theatres
			93119	Other hospitals n.e.c.
		9312		Medical and dental practice activities
			93121	Medical practitioner and specialist activities
			93122	Dentist and special dentist activities
		9319		Other human health activities
			93191	Supplementary health services or paramedical staff (practitioners)
			93192	Clinics and related health care services
			93193	Nursing services
			93194	Chiropractors and other associated health care services
			93199	Other health services
	932	9320	93200	VETERINARY ACTIVITIES
	933	9330	93300	SOCIAL WORK ACTIVITIES
94				OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICE ACTIVITIES
	940	9400	94000	SEWAGE AND REFUSE DISPOSAL, SANITATION AND SIMILAR ACTIVITIES
95				ACTIVITIES OF MEMBERSHIP ORGANISATIONS N.E.C.
	951			ACTIVITIES OF BUSINESS, EMPLOYERS AND PROFESSIONAL ORGANISATIONS
		9511	95110	Activities of business and employers' organisations
		9512	95120	Activities of professional organisations
	952	9520	95200	ACTIVITIES OF TRADE UNIONS
	959			ACTIVITIES OF OTHER MEMBERSHIP ORGANISATIONS
		9591	95910	Activities of religious organisations
		9592	95920	Activities of political organisations
		9599	95990	Activities of other membership organisations n.e.c.
96				RECREATIONAL, CULTURAL AND SPORTING ACTIVITIES
	961			MOTION PICTURE, RADIO, TELEVISION AND OTHER ENTERTAINMENT ACTIVITIES
		9611		Motion picture and video production and distribution
			96111	Motion picture and video production and distribution
			96112	Related activities - film and tape renting to other industries, booking, delivery and storage
		9612		Motion picture projection
			96121	Motion picture projection by cinemas
			96122	Motion picture projection by driven cinemas
		9613	96130	Radio and television activities
		9614	96140	Dramatic arts, music and other arts activities
		9619	96190	Other entertainment activities n.e.c.
	962	9620	96200	NEWS AGENCY ACTIVITIES
	963			LIBRARY, ARCHIVES, MUSEUMS AND OTHER CULTURAL ACTIVITIES
		9631	96310	Library and archives activities
		9632	96320	Museum activities and preservation of historical sites and building
		9633	96330	Botanical and zoological gardens and nature reserve activities
	964			SPORTING AND OTHER RECREATIONAL ACTIVITIES
		9641	96410	Sporting activities
		9649	96490	Other recreational activities
99				OTHER SERVICE ACTIVITIES
	990			OTHER SERVICE ACTIVITIES
		9901	99010	Washing and (dry-) cleaning of textiles and fur products
		9902		Hairdressing and other beauty treatment
			99021	Men's hairdressing
			99022	Ladies' hairdressing
			99023	Men's and ladies' hairdressing
		9903	99030	Funeral related activities
		9909	99090	Other service activities n.e.c.

APPENDIX B

INTERNATIONAL ENERGY AGENCY FUEL DEFINITIONS (IEA, 1998a)

B.1 SOLID FUELS

1. **Hard Coal** : Hard coal refers to coal of gross calorific value greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis and with a mean random reflectance of vitrinite of at least 0.6. Hard coal comprises:

   A. *Coking Coal* : Coal with a quality that allows the production of a coke suitable to support a blast furnace charge. The following coal classification codes cover those coals which would fall into this category:

International classification codes (UN, Geneva, 1956)	323, 333, 334, 423, 433, 434, 435, 523, 533, 534, 535, 623, 633, 634, 635, 723, 733, 823
USA classification	Class II Group 2 " Medium Volatile Bituminous".
British classification	Classes 202, 203, 204, 301, 302, 400, 500, 600
Polish classification	Classes 33, 34, 35.1, 35.2, 36, 37
Australian classification	Classes 4A, 4B, 5.

   B. *Steam Coal (Other Bituminous Coal and Anthracite)* : Steam coal is used for steam raising and space heating purposes and includes all Anthracite coals and Bituminous coals not included under Coking coal.

2. **Sub-Bituminous Coal** : Non-agglomerating coals with a gross calorific value between 17 435 kJ/kg (4 165 kcal/kg) and 23 865 kJ/kg (5 700 kcal/kg) containing more than 31% volatile matter on a dry mineral matter free basis.

3. **Lignite:** Non-agglomerating coals with a gross calorific value less than 17 435 kJ/kg (4 165 kcal/kg) and greater than 31% volatile matter on a dry mineral matter free basis. Oil shale and tar sands combusted directly in power and heat plants should be reported in this category.

4. **Peat** : Combustible soft, porous or compressed, fossil sedimentary deposit of plant origin with high water content (up to 90 per cent in the raw state) easily cut, of light to dark brown colour.

5. **Patent Fuel** : A composition fuel manufactured from coal fines by shaping with the addition of a binding agent (pitch). Note that the amount of patent fuel produced can be slightly higher than the amount of coal consumed in the transformation process because of the addition of pitch.

6. **Coke Oven Coke:** The solid product obtained from carbonisation of coal, principally coking coal, at high temperature, it is low in moisture and volatile matter. Coke oven coke is used mainly in the iron and steel industry acting as energy source and chemical agent. Semi-coke, the solid product obtained from carbonisation of coal at low temperature, should be included in this category. Semi-coke is used as a domestic fuel or by the transformation plant itself. This heading also includes coke and semi-coke made from lignite.

7. **Gas Coke:** A by-product of hard coal used for production of town gas in gas works. Gas Coke is used for heating purposes.

8. **BKB (Braunkohlenbriketts) (Includes peat briquettes) :** A composition fuel manufactured from brown coal. The brown coal is crushed, dried and moulded under high pressure into an even-shaped briquette without the addition of binders. German production of lignite dust is included in this category.

9. **Gas Works Gas:** Covers all types of gases including substitute natural gas produced in public utility or private plants, whose main purpose is manufacture, transport and distribution of gas. It includes gas produced by carbonisation (including gas produced by coke ovens and transferred to gas works gas) reported under the "production" row, by total gasification with or without enrichment with oil products (LPG, residual fuel oil, etc.), by cracking of natural gas, and by reforming and simple mixing of gases and/or air, reported under the "from other sources" row. Substitute natural gas is a high calorific value gas, manufactured by chemical conversion of a hydrocarbon fossil fuel. It is chemically and physically interchangeable with natural gas and is usually distributed through the natural gas grid. The main raw materials for manufacture of substitute natural gas are : coal, oil and oil shales. Substitute natural gas is distinguished from other manufactured gases by its high heat value (above 8 000 kcal/m^3) and by its high methane content (above 85%). Substitute natural gas produced by synthesis from fuels other than coal based should also come under "from other sources".

10. **Coke Oven Gas :** Obtained as a by-product of solid fuel carbonisation and gasification operations carried out by coke producers and iron and steel plants which are not connected with gasworks and municipal gas plants.

11. **Blast Furnace Gas :** Obtained as a by-product in operating blast furnaces; it is recovered on leaving the furnaces and used partly within

the plant and partly in other steel industry processes or in power stations equipped to burn it.

12. **Oxygen Steel Furnace Gas** : Obtained as a by-product of the production of steel in an oxygen furnace; it is recovered on leaving the furnace. The gas is also known as converter gas or LD gas. The quantity of fuel should be reported on a **gross** calorific value.

13. **Solid Biomass and Animal Products** : Comprises products combusted directly to produce heat and/or power. Included are wood, other vegetal materials and wastes (including wood waste, wood chips, sawdust and crops used for energy production), charcoal, animal materials/wastes and sulphite lies, also known as 'black liquor' (an alkaline spent liquor from the digesters in the production of sulphate or soda pulp during the manufacture of paper. The energy content derives from the lignin removed from the wood pulp). Biomass is defined as any plant matter used directly as fuel or converted into fuels or electricity and/or heat. The quantity of fuel used should be reported on a **net** calorific value basis. Note that alcohols and esters produced from biomass for energy use should be reported in the Oil Questionnaire.

14. **Industrial Wastes** : Comprises solid and liquid products combusted directly to produce heat and/or power that are not reported in the category 'Solid Biomass and Animal Products' above. The quantity of fuel used should be reported on a **net** calorific value basis.

15. **Municipal Solid Wastes:** Comprises products that are combusted directly to produce heat and/or power and comprises wastes produced by the Residential and Commercial and Public Services Sectors that are collected by local authorities for disposal in a central location. Hospital waste should be reported in this category. The quantity of fuel used should be reported on a **net** calorific value basis.

16. **Gases derived from Biomass and Wastes:** Gases that are derived principally from the fermentation of biomass and solid wastes and combusted to produce heat and/or power. Included in this category are landfill gas and sludge gas (sewage gas and gas from animal slurries). The quantity of fuel used should be reported on a **net** calorific value basis.

B.2 CRUDE OIL AND PETROLEUM PRODUCTS

Please note: in the definitions, petrochemical feedstocks refer to all oil products which are used as raw material in the petrochemical industry for steamcracking, aromatics plants. E.g. naphtha, LPG, light and heavy gasoil, reformate etc.

1. Crude Oil

Crude oil is a mineral oil of natural origin comprising a mixture of hydrocarbons and associated impurities, such as sulphur. It exists in the liquid phase under normal surface temperature and pressure and its physical characteristics (density, viscosity, etc.) are highly variable. This category includes field or lease condensate recovered from associated and non-associated gas where it is commingled with the commercial crude oil stream.

2. Natural Gas Liquids (NGL)

NGL are liquid or liquefied hydrocarbons recovered from natural gas in separation facilities or gas processing plants. Natural gas liquids include ethane, propane, butane (normal and iso-), (iso) pentane and pentanes plus (sometimes referred to as natural gasoline or plant condensate).

3. Refinery Feedstocks

A refinery feedstock is a processed oil destined for further processing (e.g. straight run fuel oil or vacuum gas oil) excluding blending. With further processing, it will be transformed into one or more components and/or finished products. This definition also covers returns from the petrochemical industry to the refining industry (e.g. pyrolysis gasoline, C4 fractions, gasoil and fuel oil fractions).

4. Additives/Oxygenates

Additives are non-hydrocarbon compounds added to or blended with a product to modify fuel properties (octane, cetane, cold properties, etc.) e.g. alcohols (methanol, ethanol), ethers (such as MTBE [methyl tertiary butyl ether], ETBE [ethyl tertiary butyl ether], TAME [tertiary amyl methyl ether] or esters [e.g. rapeseed or dimethylester, etc.] and chemical compounds (such as TML [tetramethyl lead] or TEL [tetraethyl lead]) and detergents.

Note: Quantities of ethanol reported in this category should relate to the quantities destined for fuel use.

5. Other Hydrocarbons

This category includes synthetic crude oil from tar sands, oil shale, etc., liquids from coal liquefaction, hydrogen and emulsified oils (e.g. Orimulsion).

Note on the reporting of emulsified oils:

All imports of emulsified oils (e.g. Orimulsion) should be reported as imports of "Other Hydrocarbons" (cell EE in Table 1). As these oils do not need further processing in a refinery, report these quantities as Direct Use (cell GE in Table 1) and Primary Product Receipts in the "Bitumen" category of the Supply of Finished Products report (Table 2/2). Any production of emulsified oils should appear as indigenous production of "Other Hydrocarbons" (cell AE in Table 1). Report all quantities in physical weight of the emulsion (i.e. including the water content).

6. Refinery gas (not liquefied)

Refinery gas includes a mixture of non-condensable gases mainly consisting of hydrogen, methane, ethane and olefins obtained during distillation of crude oil or treatment of oil products (e.g. cracking) in refineries. This also includes gases which are returned from the petrochemical industry.

7. Ethane

A naturally gaseous straight-chain hydrocarbon (C_2H_6) extracted from natural gas and refinery gas streams.

8. Liquefied Petroleum Gases (LPG)

LPG are light saturated paraffinic hydrocarbons derived from the refinery processes, crude oil stabilisation and natural gas processing plants. They consist mainly of propane (C_3H_8) and butane (C_4H_{10}) or a combination of the two. They are normally liquefied under pressure for transportation and storage.

9. Naphtha

Naphtha is a feedstock destined for either the petrochemical industry (e.g. ethylene manufacture or aromatics production) or for gasoline production by reforming or isomerisation within the refinery. Naphtha comprises material in the 30°C and 210°C distillation range or part of this range.

Naphtha imported for blending is reported as an import of naphtha, then shown on the interproduct transfer row, as a negative entry for Naphtha, and a positive entry for the corresponding finished product (e.g. gasoline).

10. Motor Gasoline

Motor gasoline consists of a mixture of light hydrocarbons distilling between 35°C and 215°C. It is used as a fuel for land based spark ignition engines. Motor gasoline may include additives, oxygenates and octane enhancers, including lead compounds such as TEL (tetraethyl lead) and TML (tetramethyl lead).

- **Unleaded Motor Gasoline:** motor gasoline where lead compounds have not been added to enhance octane rating. It may contain traces of organic lead.
- **Leaded Motor Gasoline:** motor gasoline with TEL (tetraethyl lead) and/or TML (tetramethyl lead) added to enhance octane rating.

This category includes motor gasoline blending components (excluding additives/oxygenates), e.g. alkylates, isomerate, reformate, cracked gasoline destined for use as finished motor gasoline.

11. Aviation Gasoline

This is motor spirit prepared especially for aviation piston engines, with an octane number suited to the engine, a freezing point of -60°C and a distillation range usually within the limits of 30°C and 180°C.

12. Gasoline Type Jet Fuel (Naphtha type Jet Fuel or JP4)

This includes all light hydrocarbon oils for use in aviation turbine power units, distilling between 100°C and 250°C. They are obtained by blending kerosenes and gasoline or naphthas in such a way that the aromatic content does not exceed 25% in volume and the vapour pressure is between 13.7kPa and 20.6kPa.

13. Kerosene Type Jet Fuel

This is a distillate used for aviation turbine power units. It has the same distillation characteristics between 150°C and 300°C (generally not above 250°C) and flash point as kerosene. In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA).

14. Other Kerosene

Kerosene comprises refined petroleum distillate and is used in sectors other than aircraft transport. It distils between 150°C and 300°C.

15. Gas/Diesel Oil (Distillate Fuel Oil)

Gas/diesel oil is primarily a medium distillate distilling between 180°C and 380°C. Several grades are available depending on uses:

- diesel oil for diesel compression ignition (cars, trucks, marine, etc.);
- light heating oil for industrial and commercial uses;
- other gas oil including heavy gas oils which distil between 380°C and 540°C and which are used as petrochemical feedstocks.

16. Fuel Oil

This covers all residual (heavy) fuel oils (including those obtained by blending). Kinematic viscosity is above 10 cSt at 80°C. The flash point is always above 50°C and density is always more than 0.90 kg/l.

Low sulphur content: Heavy fuel oil with sulphur content lower than 1%.

High sulphur content: Heavy fuel oil with sulphur content of 1% or higher.

17. White Spirit and SBP

White Spirit and SBP are defined as refined distillate intermediates with a distillation in the naphtha/kerosene range. They are sub-divided as:

i. Industrial Spirit (SBP) Light oils distilling between 30°C and 200°C. There are 7 or 8 grades of industrial spirit, depending on the position of the cut in the distillation range. The grades are defined according to the temperature difference between the 5% volume and 90% volume distillation points (which is not more than 60°C).

ii. White Spirit: Industrial spirit with a flash point above 30°C. The distillation range of white spirit is 135° to 200°C.

18. Lubricants

Lubricants are hydrocarbons produced from distillate or residue; they are mainly used to reduce friction between bearing surfaces. This category includes all finished grades of lubricating oil, from spindle oil to cylinder oil,

and those used in greases, including motor oils and all grades of lubricating oil base stocks.

19. Bitumen

Bitumen is a solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in colour, obtained as a residue in the distillation of crude oil, by vacuum distillation of oil residues from atmospheric distillation. Bitumen is often referred to as asphalt and is primarily used for construction of roads and for roofing material. This category includes fluidised and cut back bitumen.

20. Paraffin Waxes

These are saturated aliphatic hydrocarbons. These waxes are residues extracted when dewaxing lubricant oils. They have a crystalline structure which is more-or-less fine according to the grade. Their main characteristics are as follows: they are colourless, odourless and translucent, with a melting point above 45°C.

21. Petroleum Coke

Petroleum coke is a black solid residue, obtained mainly by cracking and carbonising residue feedstock, tar and pitches in processes such as delayed coking or fluid coking. It consists mainly of carbon (90 to 95%) and has a low ash content. It is used as a feedstock in coke ovens for the steel industry, for heating purposes, for electrode manufacture and for production of chemicals. The two most important qualities are "green coke" and "calcinated coke". This category also includes "catalyst coke" deposited on the catalyst during refining processes; this coke is not recoverable and is usually burned as refinery fuel.

22. Other Products

All products not specifically mentioned above, for example: tar and sulphur. This category also includes aromatics (e.g. BTX or benzene, toluene and zylene) and olefins (e.g. propylene) produced within refineries.

B.3 NATURAL GAS

Natural gas comprises gases, occurring in underground deposits, whether liquefied or gaseous, consisting mainly of methane. It includes both "non-associated" gas originating from fields producing hydrocarbons only in gaseous form, and "associated" gas produced in association with crude oil as

well as methane recovered from coal mines (colliery gas). Manufactured gas (produced from municipal or industrial waste, or sewage) should be reported in the Annual Questionnaire on Solid Fuels, Wastes and Manufactured Gases [EP(96)2].

B.4 ELECTRICITY AND HEAT

The questionnaires seek information on the fuel requirements for, and the generation of electricity and heat according to producer and generating plant types.

Types of Producer:

Producers are classified according to the purpose of production:

Public supply undertakings generate electricity and/or heat for sale to third parties, *as their primary activity.* They may be privately or publicly owned. Note that the sale need not take place through the public grid.

Autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.

Types of Plant:

The separation of fuel use and electricity/heat generation statistics according to the type of plant (i.e. electricity (only), heat (only) or combined electricity and heat) will normally be conducted using statistics collected at the plant level, i.e. generating stations comprising one or more generating sets or units. The definitions given below have been prepared on this assumption. However, when a country has data for the electricity and heat output, and fuel inputs, for each of the generating units within a plant, these data should be used to prepare the report. In this case the definitions set out below will need to be interpreted on the unit basis rather than on the plant basis.

Electricity Only refers to a plant which is designed to produce electricity only. If one or more units of the plant is a CHP unit (*see below*) then the whole plant is designated as a CHP plant.

Combined Heat and Power (CHP) refers to a plant which is designed to produce both heat and electricity. UNIPEDE refers to these as co-generation power stations. If possible, fuel inputs and electricity/heat outputs should be reported on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above should be adopted.

Heat Only refers to a plant which is designed to produce heat only.

Heat delivered from CHP or Heat Only plants may be used for process or space heating purposes in any sector of economic activity including the Residential Sector.

It should be noted that:

Electricity production reported for *Autoproducer Electricity* or *Autoproducer CHP* should be the total quantity of electricity generated.

All heat production from *Public CHP* and *Public Heat* plants should be reported. However, heat production reported for *Autoproducer CHP and Autoproducer Heat* plants should comprise only the heat sold to third parties. Heat consumed by autoproducers should not be included.

Report in the transformation sector only those quantities of fuels used to generate the amounts of electricity and heat reported in the questionnaire. The quantities of fuel consumed for the production of heat which is not sold will remain in the figures for the final consumption of fuels by the relevant sector of economic activity.

APPENDIX C

SAMPLES OF ENERGY PRICE OUTPUTS FOR SOUTH AFRICA

(Extracted from Cooper (1998c)

REPORT 2

PETROLEUM PRODUCTS PRICE REPORT

PETROL PRICES - Individual Components

Mogas 93 - Coast Price

March 1998

Institute for Energy Studies
Rand Afrikaans University

TABLE 2
Nominal Petrol Price - Individual Components
Mogas 93 - Coast Price
(c/l)

	1	2	3	4	5	6	7	8	9	10	11
Date of change	IBLC	Fuel Tax	Customs and Excise	Equalisation Fund	MMF	CRSF	Transport	Wholesale Margin	Delivery Cost	Retail Margin	Pump Price
01-01-1987	26.74	23.50	4.00	5.70	3.60			3.56	1.70	5.20	74.00
16-02-1987	24.74	23.50	4.00	5.70	3.60			3.56	1.70	7.20	74.00
01-07-1987	24.54	23.50	4.00	5.70	3.60		0.20	3.56	1.70	7.20	74.00
01-01-1988	24.34	23.50	4.00	5.70	3.60		0.20	3.56	1.90	7.20	74.00
01-04-1988	24.34	22.50	4.00	6.70	3.60		0.20	3.56	1.90	7.20	74.00
01-09-1988	36.04	22.90	4.00	7.00	3.60		0.20	3.56	1.90	7.80	87.00
16-01-1989	33.24	31.90	4.00	7.00	3.60		0.20	5.56	2.10	8.40	96.00
15-04-1989	39.94	31.90	4.00	7.00	3.60		0.20	5.56	2.10	8.70	103.00
15-07-1989	45.94	31.90	4.00	7.00	3.60		0.20	5.56	2.10	8.70	109.00
01-12-1989	44.44	31.90	4.00	7.00	3.60		0.20	5.56	2.10	10.20	109.00
01-01-1990	44.14	31.90	4.00	7.00	3.60		0.20	5.56	2.40	10.20	109.00
01-07-1990	44.34	31.90	4.00	7.00	3.40		0.20	5.56	2.40	10.20	109.00
04-09-1990	54.34	31.90	4.00	7.00	3.40		0.20	5.56	2.40	10.20	119.00
20-10-1990	84.34	31.90	4.00	7.00	3.40		0.20	5.56	2.40	12.20	151.00
12-11-1990	69.24	31.90	4.00	7.00	4.00	0.20	0.20	5.56	2.40	11.50	136.00
21-12-1990	59.24	31.90	4.00	7.00	4.00	0.20	0.20	5.56	2.40	11.50	126.00
01-01-1991	58.74	31.90	4.00	7.00	4.00	0.20	0.20	5.56	2.90	11.50	126.00
25-03-1991	48.74	36.90	4.00	7.00	4.00	0.20	0.20	5.56	2.90	11.50	121.00
23-08-1991	49.74	46.90	4.00	7.00	4.00	0.20	0.20	7.56	2.90	11.50	134.00
14-12-1991	48.24	46.90	4.00	7.00	4.00	0.20	0.20	7.56	2.90	13.00	134.00
01-01-1992	47.84	46.90	4.00	7.00	4.00	0.20	0.20	7.56	3.30	13.00	134.00
21-03-1992	45.84	54.90	4.00	7.00	4.00	0.20	0.20	9.56	3.30	13.00	142.00
01-04-1992	43.84	54.90	4.00	7.00	6.00	0.20	0.20	9.56	3.30	13.00	142.00
01-07-1992	41.74	54.90	4.00	7.00	6.00	0.20	0.20	9.56	3.30	15.10	142.00
10-10-1992	44.74	54.90	4.00	7.00	6.00	0.20	0.20	13.56	3.30	15.10	149.00
01-01-1993	44.54	54.90	4.00	7.00	6.00	0.20	0.20	13.56	3.50	15.10	149.00
02-04-1993	50.54	60.90	4.00	7.00	9.00	0.20	0.20	13.56	3.50	15.10	164.00
15-09-1993	56.54	60.90	4.00	7.00	9.00	0.20	0.20	14.06	3.50	15.60	171.00
30-10-1993	54.54	60.90	4.00	7.00	9.00	0.20	0.20	14.06	3.50	15.60	169.00
17-12-1993	52.54	60.90	4.00	7.00	9.00	0.20	0.20	14.06	3.50	15.60	167.00
17-02-1994	43.54	60.90	4.00	13.00	9.00	0.20	0.20	14.06	3.50	15.60	164.00
18-06-1994	56.14	60.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	173.00
05-10-1994	50.14	60.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	167.00
02-11-1994	49.14	60.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	166.00
06-12-1994	50.14	60.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	167.00
01-02-1995	46.14	60.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	163.00
01-03-1995	51.14	60.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	168.00
04-04-1995	48.14	60.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	165.00

TABLE 2
Nominal Petrol Price - Individual Components
Mogas 93 - Coast Price
(c/l)

	1	2	3	4	5	6	7	8	9	10	11
Date of change	IBLC	Fuel Tax	Customs and Excise	Equalisation Fund	MMF	CRSF	Transport	Wholesale Margin	Delivery Cost	Retail Margin	Pump Price
05-04-1995	56.14	61.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	174.00
03-05-1995	58.14	62.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	15.60	177.00
02-08-1995	58.14	62.90	4.00	9.40	9.00	0.20	0.20	14.06	3.50	16.60	178.00
06-09-1995	57.04	62.90	4.00	9.40	9.00	0.20	0.20	14.06	4.10	17.10	178.00
04-10-1995	58.04	62.90	4.00	9.40	9.00	0.20	0.20	14.06	4.10	18.10	180.00
01-11-1995	55.04	62.90	4.00	9.40	9.00	0.20	0.20	14.06	4.10	18.10	177.00
06-12-1995	53.04	62.90	4.00	9.40	9.00	0.20	0.20	14.06	5.10	18.10	176.00
03-01-1996	52.04	62.90	4.00	9.40	9.00	0.20	0.20	14.06	5.10	18.10	175.00
07-02-1996	51.04	62.90	4.00	9.40	9.00	0.20	0.20	14.06	5.10	18.10	174.00
06-03-1996	51.04	62.90	4.00	9.40	9.00	0.20	0.20	14.06	5.10	18.10	174.00
03-04-1996	56.04	69.10	4.00	6.40	9.00		0.20	14.06	5.10	18.10	182.00
01-05-1996	70.04	69.10	4.00	6.40	9.00		0.20	14.06	5.10	18.10	196.00
06-06-1996	83.04	69.10	4.00	6.40	9.00		0.20	14.06	5.10	18.10	209.00
03-07-1996	82.04	70.10	4.00	5.40	9.00		0.20	14.06	5.10	18.10	208.00
07-08-1996	73.04	71.60	4.00	5.40	10.50		0.20	14.06	5.10	18.10	202.00
01-09-1996	70.04	71.60	4.00	5.40	10.50		0.20	14.06	5.10	18.10	199.00
01-10-1996	71.04	71.60	4.00	5.40	10.50		0.20	14.06	5.10	18.10	200.00
01-11-1996	74.04	71.60	4.00	5.40	10.50		0.20	14.06	5.10	18.10	203.00
01-12-1996	82.04	71.60	4.00	5.40	10.50		0.20	14.06	5.10	18.10	211.00
01-01-1997	85.04	71.60	4.00	5.40	10.50		0.20	14.06	5.10	18.10	214.00
05-02-1997	84.04	72.60	4.00	4.40	10.50		0.20	14.06	5.10	18.10	213.00
01-03-1997	80.04	72.60	4.00	4.40	10.50		0.20	14.06	5.10	18.10	209.00
02-04-1997	82.04	76.60	4.00	0.40	10.50		0.20	14.06	5.10	18.10	211.00
07-05-1997	83.04	76.60	4.00	0.40	10.50		0.20	14.06	5.10	18.10	212.00
04-06-1997	77.04	76.60	4.00	0.40	10.50		0.20	14.06	5.10	18.10	206.00
02-07-1997	74.04	76.60	4.00	0.40	10.50		0.20	14.06	5.10	18.10	203.00
06-08-1997	74.04	76.60	4.00	0.40	10.50		0.20	14.06	5.10	18.10	203.00
03-09-1997	79.04	76.60	4.00	0.40	10.50		0.20	14.06	5.10	18.10	208.00
01-10-1997	80.04	76.60	4.00	0.40	10.50		0.20	14.06	5.10	18.10	209.00
05-11-1997	79.04	76.60	4.00	0.40	12.50		0.20	16.06	5.10	20.10	214.00
03-12-1997	80.04	76.60	4.00	0.40	12.50		0.20	16.06	5.10	20.10	215.00
07-01-1998	76.04	76.60	4.00	0.40	12.50		0.20	16.06	5.10	20.10	211.00
04-02-1998	71.44	76.60	4.00	0.40	14.50		0.20	16.06	5.10	22.70	211.00
04-03-1998	66.44	76.60	4.00	0.40	14.50		0.20	16.06	5.10	22.70	206.00

Explanatory Notes.

Table 2:

1. Price component data was provided by the Department of Minerals and Energy (DME).
2. IBLC (col. 1) = In-bond landed cost.
3. MMF (col. 5) = Multilateral Motor Vehicle Fund.
4. CRSF (col. 6) = Central Road Safety Fund. An amount of 0.2 c/l was allocated to this fund from 12/11/1990 to 03/04/1996.
5. Transport (col. 7) is for transporting product from the refinery to the depot (at the coast). A further amount of 10 c/l is applicable when the product is sold in Gauteng.

Figure 2:

1. The amount for the CRSF and transport (cols. 6 and 7 of Table 2) are too small to show on this graph.

FIGURE 2
Nominal Petrol Price - Individual components
Mogas 93 - Coast price

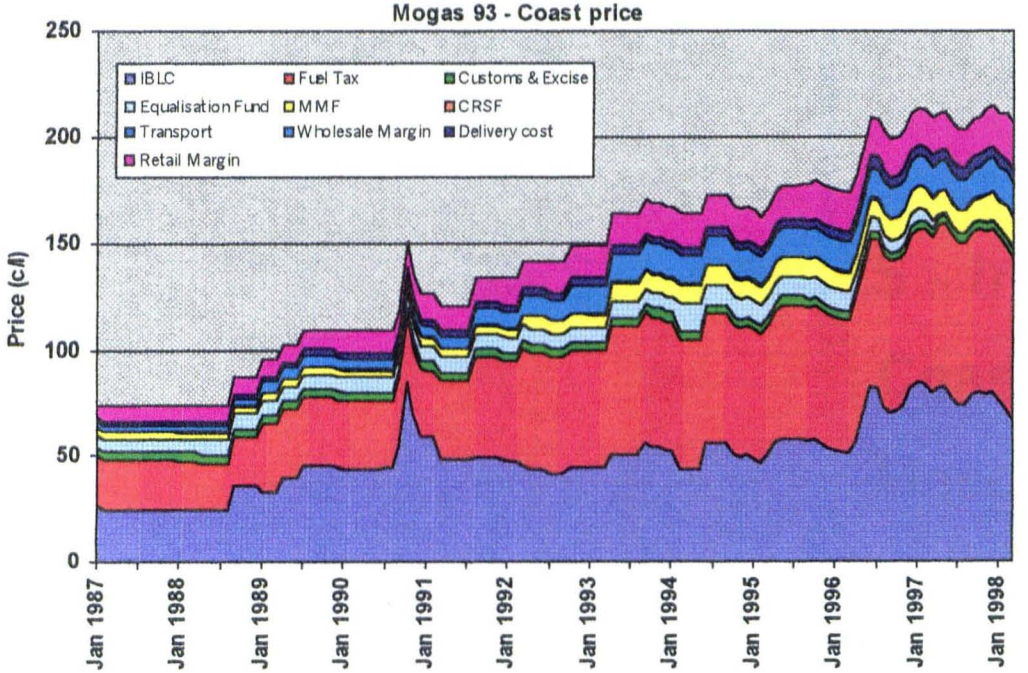
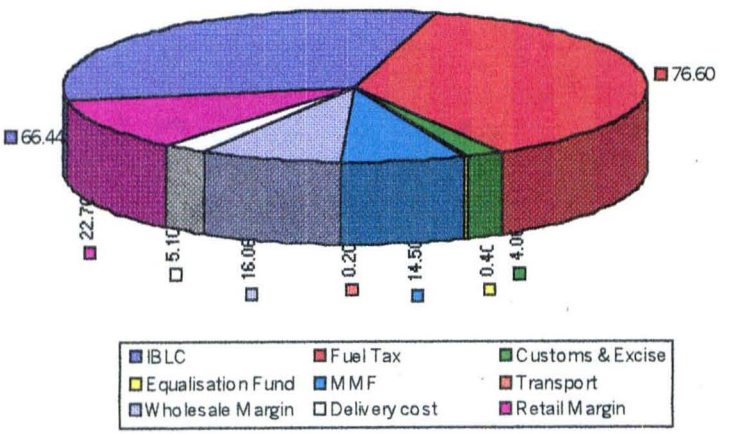


FIGURE 3
Nominal Petrol Pump Price
Individual components (c/l) as at 4 March 1998
Mogas 93 - Coast Price



REPORT 4

PETROLEUM PRODUCTS PRICE REPORT

DIESEL PRICES - Individual Components

Coast Price

March 1998

Institute for Energy Studies
Rand Afrikaans University

TABLE 4
Nominal Diesel Price - Individual Components
Coast Price
(c/l)

	1	2	3	4	5	6	7	8	9	10	11
Date of change	IBLC	Fuel Tax	Customs and Excise	Equalisation Fund	MMF	CRSF	Transport	Wholesale Margin	Retail Margin	Delivery Cost	Pump Price
01-Jul-87	31.65	24.70	4.00	5.70			0.20	3.55	5.20	1.70	75.00
01-Jan-88	29.65	24.70	4.00	5.70			0.20	5.55	5.20	1.90	75.00
01-Apr-88	30.35	18.00	4.00	6.70			0.20	5.55	5.20	1.90	70.00
01-Sep-88	36.75	19.90	4.00	6.70	2.10		0.20	5.55	5.80	1.90	81.00
01-Nov-88	36.45	19.90	4.00	7.00	2.10		0.20	5.55	5.80	1.90	81.00
16-Jan-89	35.85	28.90	4.00	7.00	2.10		0.20	5.55	6.40	2.10	90.00
15-Apr-89	47.15	28.90	4.00	7.00	2.10		0.20	5.55	7.10	2.10	102.00
15-Jul-89	49.15	28.90	4.00	7.00	2.10		0.20	5.55	7.10	2.10	104.00
01-Jan-90	49.15	28.90	4.00	7.00	2.10		0.20	5.55	7.10	2.40	104.00
01-Jul-90	46.65	31.40	4.00	7.00	1.90	0.20	0.20	5.55	7.10	2.40	104.00
04-Sep-90	53.65	31.40	4.00	7.00	1.90	0.20	0.20	5.55	10.10	2.40	114.00
20-Oct-90	78.65	31.40	4.00	7.00	1.90	0.20	0.20	5.55	12.10	2.40	141.00
12-Nov-90	69.35	31.40	4.00	7.00	2.20	0.20	0.20	5.55	12.10	2.40	132.00
21-Dec-90	66.05	31.40	4.00	7.00	2.20	0.20	0.20	5.55	11.40	2.40	128.00
01-Jan-91	66.05	31.40	4.00	7.00	2.20	0.20	0.20	5.55	11.40	2.90	128.00
25-Mar-91	59.05	33.40	4.00	7.00	2.20	0.20	0.20	5.55	11.40	2.90	123.00
01-Apr-91	57.05	33.40	4.00	7.00	2.20	0.20	0.20	7.55	11.40	2.90	123.00
23-Aug-91	57.05	41.40	4.00	7.00	2.20	0.20	0.20	7.55	11.40	2.90	131.00
01-Oct-91	55.05	41.40	4.00	7.00	2.20	0.20	0.20	9.55	11.40	2.90	131.00
01-Jan-92	55.05	41.40	4.00	7.00	2.20	0.20	0.20	9.55	11.40	3.30	131.00
21-Mar-92	55.05	47.40	4.00	7.00	2.20	0.20	0.20	9.55	11.40	3.30	137.00
01-Apr-92	53.45	47.40	4.00	7.00	3.80	0.20	0.20	9.55	11.40	3.30	137.00
01-Jul-92	49.45	47.40	4.00	7.00	3.80	0.20	0.20	13.55	11.40	3.30	137.00
01-Jan-93	49.45	47.40	4.00	7.00	3.80	0.20	0.20	13.55	11.40	3.50	137.00
02-Apr-93	56.45	53.40	4.00	7.00	5.80	0.20	0.20	13.55	11.40	3.50	152.00
15-Sep-93	61.45	53.40	4.00	7.00	5.80	0.20	0.20	14.05	11.90	3.50	158.00
30-Oct-93	59.45	53.40	4.00	7.00	5.80	0.20	0.20	14.05	11.90	3.50	156.00
17-Feb-94	58.45	53.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	156.00
18-Jun-94	58.45	53.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	156.00
05-Oct-94	56.45	53.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	154.00
02-Nov-94	55.45	53.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	153.00
07-Dec-94	57.45	53.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	155.00
04-Jan-95	59.45	53.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	157.00
01-Feb-95	58.45	53.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	156.00
05-Apr-95	58.45	54.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	157.00
03-May-95	58.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	158.00
07-Jun-95	62.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	162.00
05-Jul-95	65.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	165.00

TABLE 4
Nominal Diesel Price - Individual Components
Coast Price
(c/l)

	1	2	3	4	5	6	7	8	9	10	11
Date of change	IBLC	Fuel Tax	Customs and Excise	Equalisation Fund	MMF	CRSF	Transport	Wholesale Margin	Retail Margin	Delivery Cost	Pump Price
02-Aug-95	62.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	3.50	162.00
06-Sep-95	58.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	4.10	158.00
04-Oct-95	57.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	4.10	157.00
01-Nov-95	58.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	4.10	158.00
06-Dec-95	60.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	5.10	160.00
03-Jan-96	65.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	5.10	165.00
07-Feb-96	74.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	5.10	174.00
06-Mar-96	77.45	55.40	4.00	8.00	5.80	0.20	0.20	14.05	11.90	5.10	177.00
03-Apr-96	81.45	61.60	4.00	5.00	5.80		0.20	14.05	11.90	5.10	184.00
01-May-96	84.45	61.60	4.00	5.00	5.80		0.20	14.05	11.90	5.10	187.00
06-Jun-96	89.45	61.60	4.00	5.00	5.80		0.20	14.05	11.90	5.10	192.00
03-Jul-96	87.45	62.60	4.00	4.00	5.80		0.20	14.05	11.90	5.10	190.00
07-Aug-96	82.45	62.60	4.00	4.00	6.80		0.20	14.05	11.90	5.10	186.00
04-Sep-96	84.45	62.60	4.00	4.00	6.80		0.20	14.05	11.90	5.10	188.00
02-Oct-96	90.45	62.60	4.00	4.00	6.80		0.20	14.05	11.90	5.10	194.00
06-Nov-96	99.45	62.60	4.00	4.00	6.80		0.20	14.05	11.90	5.10	203.00
04-Dec-96	108.45	62.60	4.00	4.00	6.80		0.20	14.05	11.90	5.10	212.00
01-Jan-97	112.45	62.60	4.00	4.00	6.80		0.20	14.05	11.90	5.10	216.00
05-Feb-97	109.45	63.60	4.00	3.00	6.80		0.20	14.05	11.90	5.10	213.00
05-Mar-97	90.45	63.60	4.00	3.00	6.80		0.20	14.05	11.90	5.10	194.00
02-Apr-97	86.45	66.10	4.00	0.50	6.80		0.20	14.05	11.90	5.10	190.00
07-May-97	92.45	66.10	4.00	0.50	6.80		0.20	14.05	11.90	5.10	196.00
04-Jun-97	87.35	66.10	4.00	0.50	6.80		0.20	14.05	11.90	5.10	196.00
02-Jul-97	82.35	66.10	4.00	0.50	6.80		0.20	14.05	11.90	5.10	191.00
06-Aug-97	73.35	66.10	4.00	0.50	6.80		0.20	14.05	11.90	5.10	182.00
03-Sep-97	72.35	66.10	4.00	0.50	6.80		0.20	14.05	11.90	5.10	181.00
01-Oct-97	76.35	66.10	4.00	0.50	6.80		0.20	14.05	11.90	5.10	185.00
05-Nov-97	79.85	66.10	4.00	0.50	8.30		0.20	16.05	11.90	5.10	192.00
03-Dec-97	83.85	66.10	4.00	0.50	8.30		0.20	16.05	11.90	5.10	196.00
07-Jan-98	78.85	66.10	4.00	0.50	8.30		0.20	16.05	11.90	5.10	191.00
04-Feb-98	69.85	66.10	4.00	0.50	10.30		0.20	16.05	11.90	5.10	184.00
04-Mar-98	63.85	66.10	4.00	0.50	10.30		0.20	16.05	11.90	5.10	178.00

Explanatory Notes.

Table 4:

1. Price component data was provided by the Department of Minerals and Energy (DME).
2. IBLC (col. 1) = In-bond landed cost.
3. MMF (col. 5) = Multilateral Motor Vehicle Fund.
4. CRSF (col. 6) = Central Road Safety Fund. An amount of 0.2 c/l was allocated to this fund from 12/11/1990 to 03/04/1996.
5. Transport (col. 7) is for transporting product from the refinery to the depot (at the coast). A further amount of 10 c/l is applicable when the product is sold in Gauteng.
6. The Retail Margin is only a recomended margin.

Figure 5:

1. The amount for the CRSF and transport (columns 6 and 7 of Table 4) are too small to show on this graph.

FIGURE 5
Nominal Diesel Price - Individual components
Coast Price

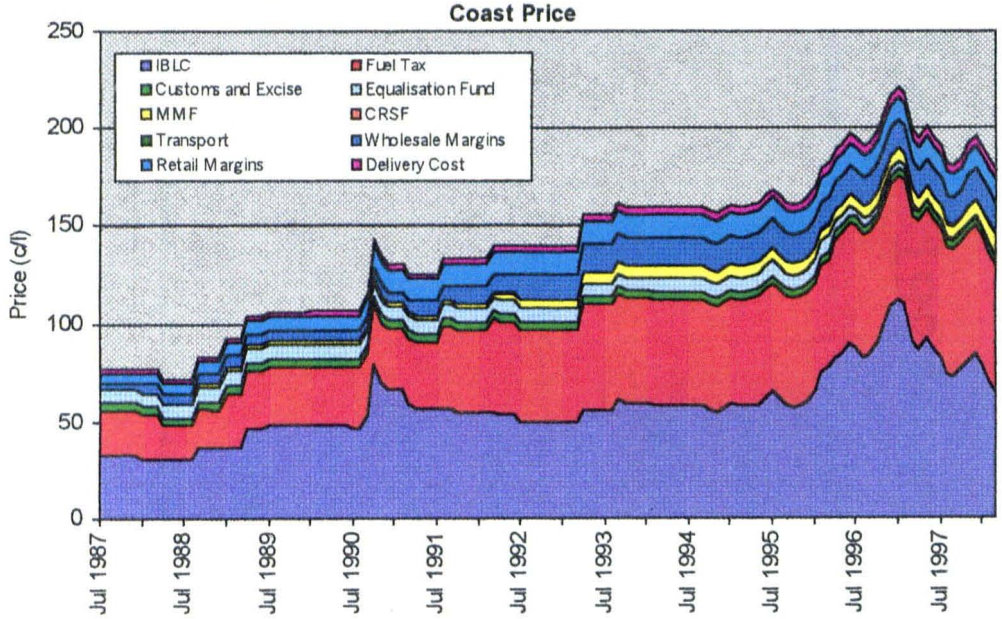
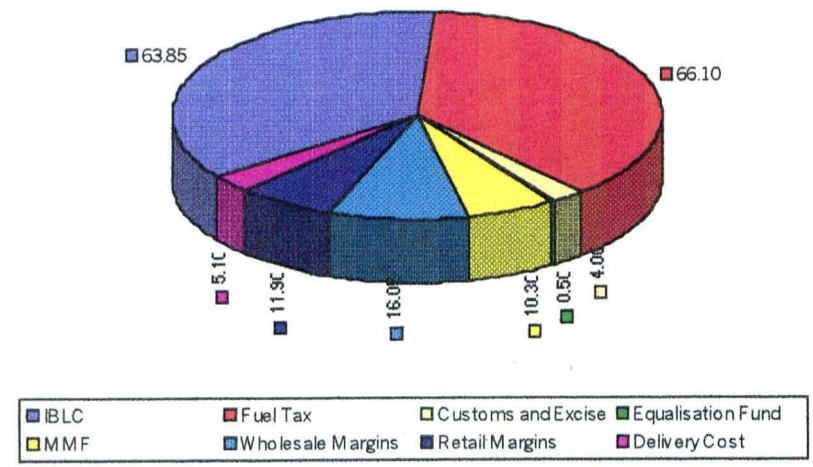


FIGURE 6
Nominal Diesel Price - Individual components (c/l) as at 4 March 1998
Coast Price



REPORT 22

INTERFUEL COMPARISONS
PRICE REPORT

Price Comparison - Business Use
1965 - 1997

Institute for Energy Studies
Rand Afrikaans University

TABLE 21

Price Comparison - Business Use

Nominal Prices (R/GJ)

	1	2	3	4	5	6
Year	Wholesale Price - Coal	Wholesale Price - Electricity	HFO (Bulk Delivery)	LPG (Bulk Direct users)	Sasol Gas Tariff A	Sasol Gas Tariff G
1965	0.08	1.42			0.57	1.14
1966	0.08	1.47			0.57	1.14
1967	0.08	1.53			0.59	1.16
1968	0.08	1.53			0.59	1.16
1969	0.09	1.56			0.61	1.18
1970	0.09	1.53			0.61	1.18
1971	0.09	1.61			0.67	1.28
1972	0.10	1.69			0.76	1.41
1973	0.12	1.81			0.83	1.54
1974	0.14	1.89			0.87	1.57
1975	0.21	2.22			1.06	1.76
1976	0.30	2.89			1.34	2.38
1977	0.36	4.28			1.68	2.93
1978	0.41	4.97			1.81	3.08
1979	0.47	5.28			1.99	3.57
1980	0.53	5.61			2.49	4.68
1981	0.59	6.33			3.10	5.82
1982	0.65	7.78	5.59		3.59	6.80
1983	0.68	9.33	5.99		3.94	7.39
1984	0.72	9.94	6.35		4.21	7.83
1985	0.79	11.44	10.58		4.68	8.72
1986	0.95	13.83	8.50		5.31	9.59
1987	1.10	15.97	8.17		5.70	10.46
1988	1.25	17.39	8.09		6.17	11.80
1989	1.47	19.17	8.63	25.41	6.78	13.52
1990	1.84	21.89	10.85	33.50	7.80	17.31
1991	2.13	23.53	10.53	32.05	9.08	23.18
1992	1.93	25.44	10.19	32.23	10.71	28.22
1993	1.90	26.64	12.03	33.60	10.89	28.22
1994	1.90	28.67	12.15	36.46	11.91	30.86
1995	2.27	32.03	14.66	38.98	12.35	31.99
1996	2.72	31.61	17.03	41.33	13.46	34.88
1997			18.83	46.11	15.01	38.90

Explanatory Notes.

Table 21:

1. This table gives comparative prices for various energy sources for "business" use, i.e. usually bulk prices.
2. All of the data is extracted from tables for the specific fuel.
3. Both the lowest and the highest tariffs for Sasol Gas are included.

FIGURE 24

Price Comparison - Business Use

Nominal Prices